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THE CAR FERRIES OF THE DANISH GOVERNMENT.

BY AXEL HOLM.

Although Denmark has been of only minor importance in the shipbuilding industry since wood has disappeared as a shipbuilding material, due partly to the necessity of importing both coal and steel and partly to the same troubles which have retarded shipbuilding in the United States, yet the country is still foremost in the construction and handling of car ferries. In fact, foreign civil engineers, both from Britain and Germany, very often pay visits to Denmark in order to study the design, construction and operation of these boats. Many years ago the numerous sounds and waterways separating the Danish islands led the railroads to resort to the use of ferries. These waters are too wide and the traffic not great enough to

only intended for railroad cars. Other vehicles are accommodated by special ferries. There are both paddle wheelers and screw steamers, and they are all built of steel (the older ones of iron), to the highest class of the Bureau Veritas, increased by the government's own requirements, based on thirty-six years of experience. As the crossings vary in length from about 2 miles at Fredericia-Strib to about 28 miles at the Gjedser-Warnemünde crossing, the types of ferries vary, too, from small single-trackers for the sheltered waters to big double-trackers for the open Baltic service.

As will be seen from the map, the ferry service takes place at eight crossings in the country, but at Malmoe and from

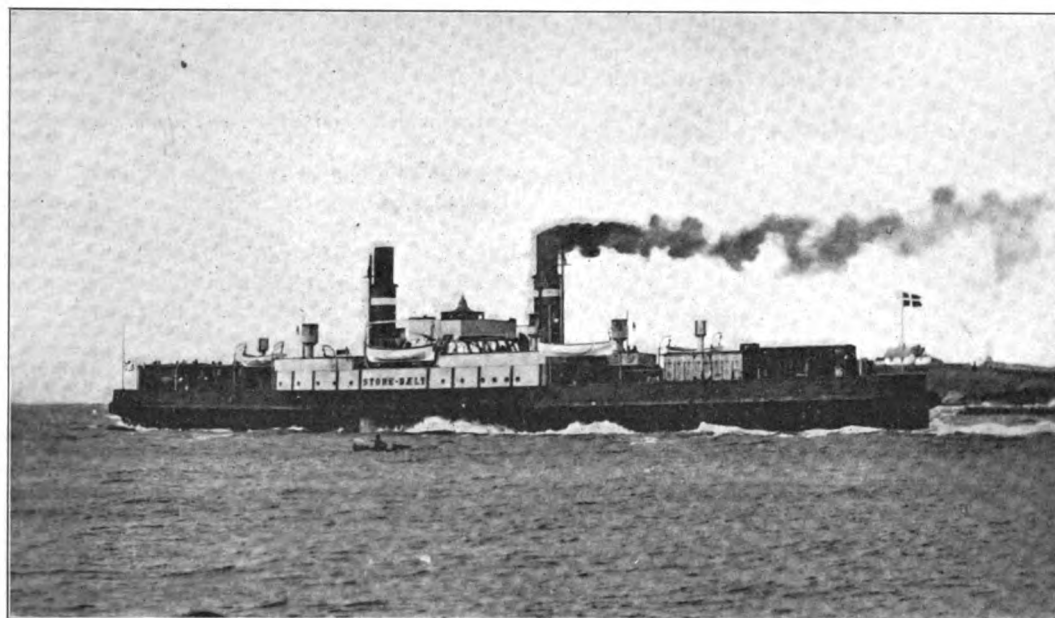


FIG. 1.—STEAM CAR FERRY STORE-BÆLT AT KORSOER.

make bridges or tunnels feasible, although bridges at the Madsuetsund and Fredericia-Strib crossings are now being considered, and a railroad tunnel under the great belt from Korsøer to Nyborg has often been under investigation.

All the principal railroad lines in Denmark, and all those using car ferries, are in charge of the government. From a very small start in the year 1872, with a single iron-paddle ferry, the *Lillebæltu*, the traffic has now grown up to a considerable extent, and so rapidly that some of the ferries had to be elongated only a few years after building, as will be seen from succeeding table. At present the government ferry fleet consists of twenty-two vessels, having a collective gross tonnage of about 15,000, exclusive of other vessels used in the railroad trade. Car floats are never used, and the ferries have only one or two tracks; those described here are

Gjedser to Warnemünde one-half of the traffic is cared for by Swedish and Meclenburger ferries, respectively. In Table I. are shown the date of opening, length of travel, number of passengers and amount of goods conveyed and number of trips for different years, etc. In reference to this, it should be remarked that before placing ferries on the routes at Gjedser-Warnemünde and Elsinore-Helsingborg the government railroads had steamers plying at these crossings from 1886 and 1888, respectively, and that the ferry traffic between Copenhagen and Malmoe was cared for exclusively by the Danish ferry up to the year 1900.

In Tables II. and III. are shown names, place of service and full data for the entire ferry fleet, and from these are selected for further description and illustration by drawings a specimen of each type, together with one of the ice-breaking ferries

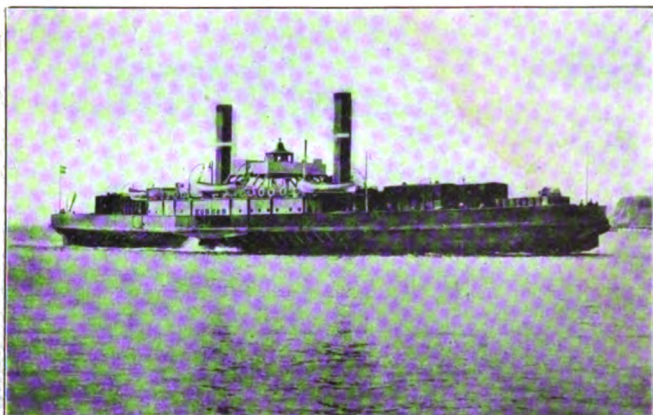


FIG. 2.—PADDLE-WHEEL FERRY KORSOER.

kept in reserve for hard winter service, viz.: the *Christian IX.*, *Prinsesse Alexandrine*, *Kjøbenhavn* and *Jylland*. Besides these ferries and those kept in reserve for extra hard winter service there are the four powerful ice-breaking steamers *Staerkodder*, *Mjølner*, *Thor* and *Thyr*, of 553, 497, 497 and 518 gross tons and 600, 800, 800 and 800 indicated horsepower, respectively, but as they are not designed for carrying cars they are omitted here.

The twin-screw, double-track ferry *Christian IX.*, plying on the Korsoer-Nyborg route, is the government's latest addition to its ferry fleet. As she was built during the year 1908 she represents all the newest improvements, and appears as a very handsome and well fitted vessel. The trial trip took place on Oct. 20, and, having finished this to the highest satisfaction, the ferry went into commission. She is built of steel to the highest class Bureau Veritas, with extra strengthening

for resisting ice. She is 290 feet long between perpendiculars, with a breadth of 39 feet 6 inches, and a depth of 18 feet 7 inches. The frames are 6 by 3 by 14/32-inch angles for a half length amidships, reduced to 6 by 3 by 12/32-inch bulb angles at the ends. They are spaced 25 inches apart. In the engine and boiler rooms deep frames, consisting of 8 by 3 by 16/32-inch bulb angles are fitted. There are no web frames used. The reverse frames are 3 by 3 by 11/32-inch angles, and where these are not fitted a 3-inch flange is turned on the



FIG. 4.—ICE-BREAKING FERRY JYLLAND.

floors. The reverse frames under the engines and boilers are single angles, 5 by 3½ by 18/32 inches, extending to the lower turn of the bilge. The floors are 23 inches wide, and in the engine and boiler rooms 15/32 inch thick; elsewhere they are 15/32 inch thick reduced to 11/32 at the ends.

No double bottom is fitted, but wing tanks are provided in the boiler room on each side, containing about 60 tons of water ballast each for trimming the vessel when unevenly loaded, the amount of ballast being controlled by a powerful centrifugal pumping plant in the after stokehold. Seven watertight bulkheads, extending to the main deck, divide the hull into eight watertight compartments. Steering is accomplished by means of two steam-operated rudders, the after one being balanced, and the transom here cut away in order to facilitate



FIG. 3.—MAP OF DENMARK, SHOWING FERRY CROSSINGS AND PRINCIPAL RAIL-ROAD LINES BELONGING TO THE GOVERNMENT.

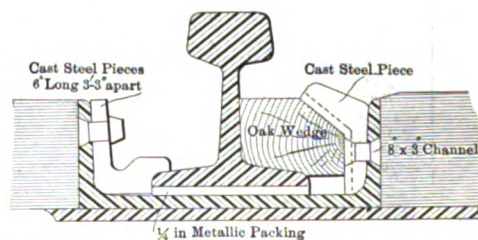


FIG. 5.—DETAIL OF RAIL FASTENING ON FERRY CHRISTIAN IX.

the turning of the rudder. The forward one is of the ordinary bow rudder type.

As may be seen from the body plan, the hull is very well designed to provide for speed, stability and easy motion, and like all these ferries the deck sheer is only slight, corresponding with the camber of the beams. The center line of the deck is thus straight. As on all other ferries a heavy, double wooden fender is carried all round the deck outboard, just fitting the shape of the ferry berths.

The drawings show clearly the general arrangement of accommodations. As the Danish trains carry three different class coaches on the longer routes, the ferries are arranged in the same manner, having one accommodation for the first and second classes and one for the third. On this boat pro-

vision is made for the first and second classes aft, and for the third class forward under the main deck. Of the open decks,

saloons are provided both fore and aft, as the Danish trains never run with dining cars, because long trips are always

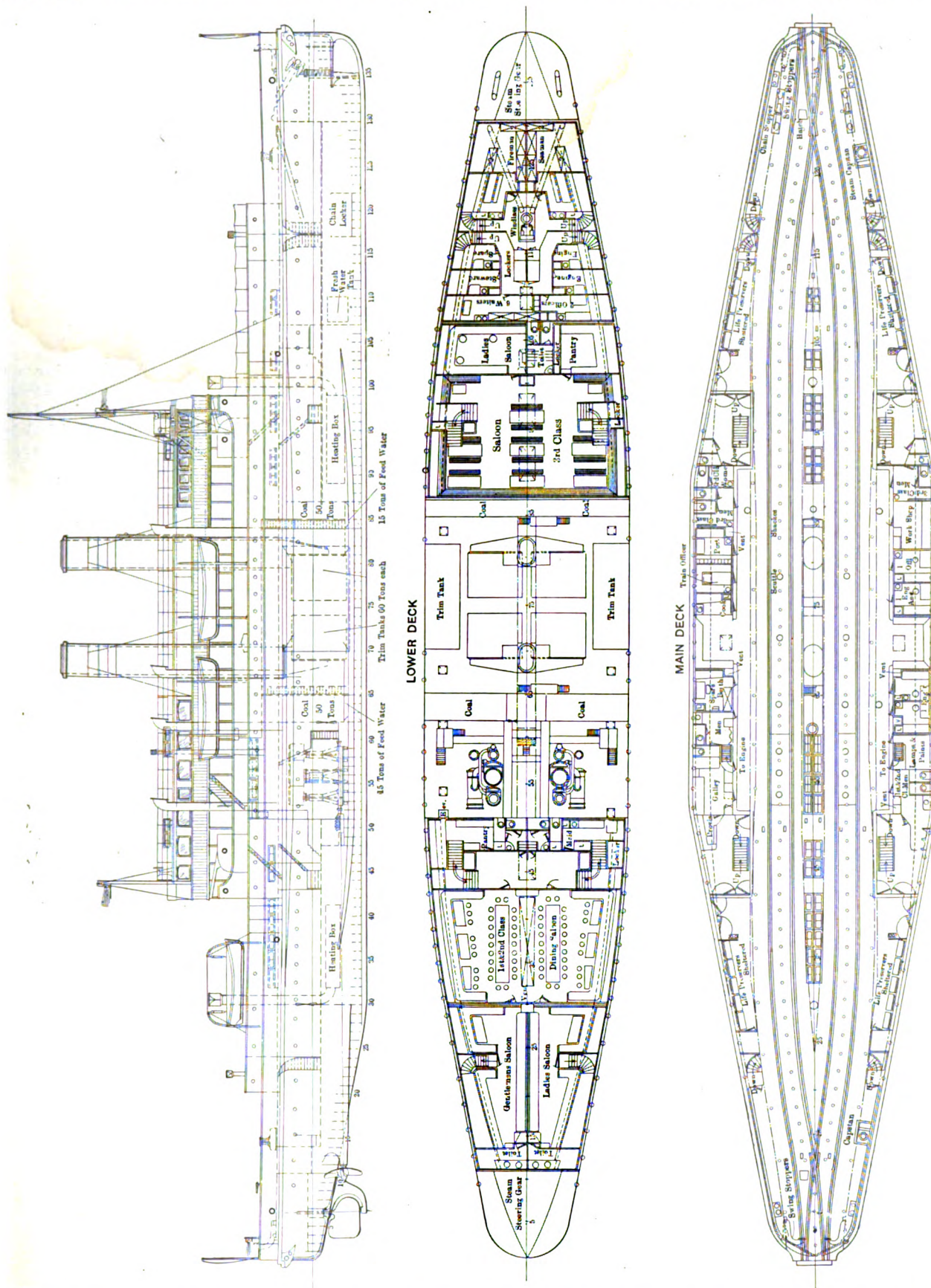


FIG. 6.—PROFILE AND DECK PLANS OF TWIN-SCREW FERRY CHRISTIAN IX.

the upper one is laid out for first and second-class use, and the main and side-house decks for third class. Large dining

interrupted by a ferry crossing, where there is a better opportunity for dining on the boat. Of the after saloons the most

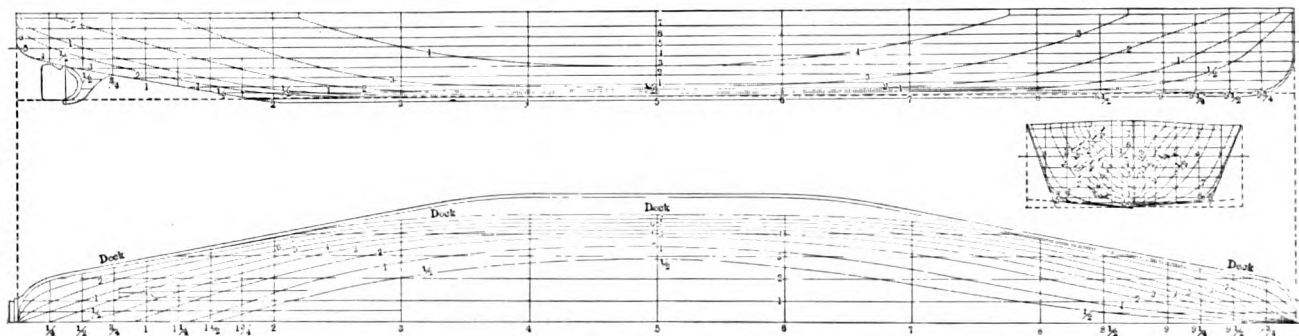


FIG. 7.—LINES OF THE CHRISTIAN IX.

important are the ladies' and gentlemen's parlors, finished in white enamel and gilt, and the dining saloon, capable of seating 84 persons, finished in carved and polished birch wood and gilt and figured leather. The third-class saloons forward are oak-painted with white ceilings. The two saloons on the upper promenade deck are finished in polished mahogany.

At the bow and stern are heavy steel shelves extending from the hull, as may be seen, to take the pads of the bridges in the ferry berths, and here the steel bulwark is cut away to leave a clear space for car shipment. Wooden bulkheads are sub-

moe and Korsoer-Nyborg. The ferry *Kjoebenhavn* (Fig. 9) may be regarded as the type formerly used for these ferries, covering the vessels *Kjoebenhavn*, *Korsoer*, *Nyborg*, *Sjaelland* and *Store-Bacht*. They are all paddle steamers, built during the years 1883-1900.

The *Kjoebenhavn* is built entirely of steel and under the same conditions as the *Christian IX*. She has neither double bottom nor wing tanks (this being arranged on the ferry *Sjaelland* by elongation of the vessel), but she is divided by four watertight bulkheads. The body of the ferry is sym-

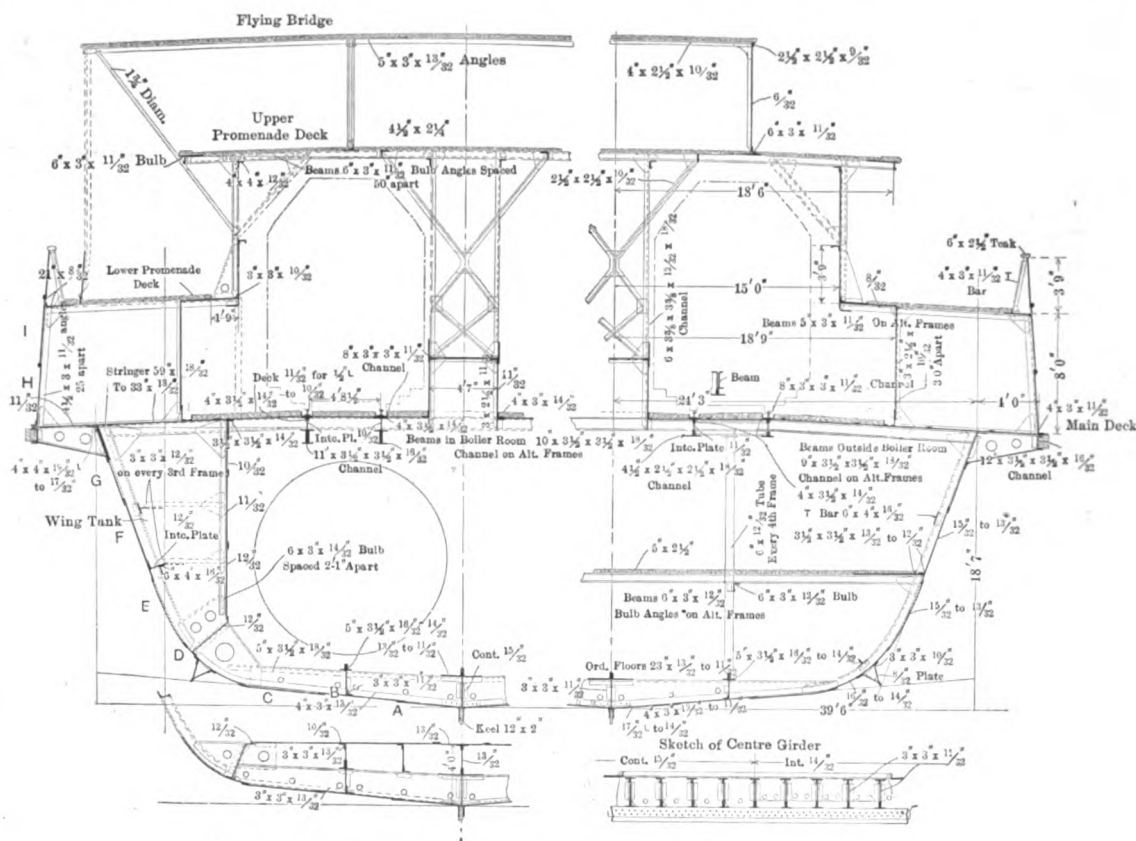


FIG. 8.—MIDSHIP SECTION OF THE CHRISTIAN IX, SHOWING PRINCIPAL SCANTLINGS.

stituted at these points. Heavy cast-steel stoppers are arranged at the ends to secure the train from accidentally running overboard, and they are made to swing out of the way when in harbor. Furthermore, there are shackles embedded in the wooden main deck alongside and between the tracks to take turnbuckles for tethering the cars. The rails themselves are wedged in channel bars, as shown on the sketch, to provide noiseless and soft running under shipment.

This ferry will probably be the future standard type for two-track ferries in the trade between Copenhagen and Mal-

metrical about the midship section, as are the general arrangements, the wheels being just in the center of the boat. Fore and aft rudders are arranged, both being of the bow-rudder type, and the transoms, fore and aft, are cut away. The arrangement of stoppers and movable bulwarks at the ends is similar to that described for the *Christian IX*. Of course this drawing shows the former kind of stoppers, consisting of heavy wooden booms, to be raised on taps at one end, but now this and all other ferries are furnished with the cast steel swing stoppers, which give at least 15 feet more

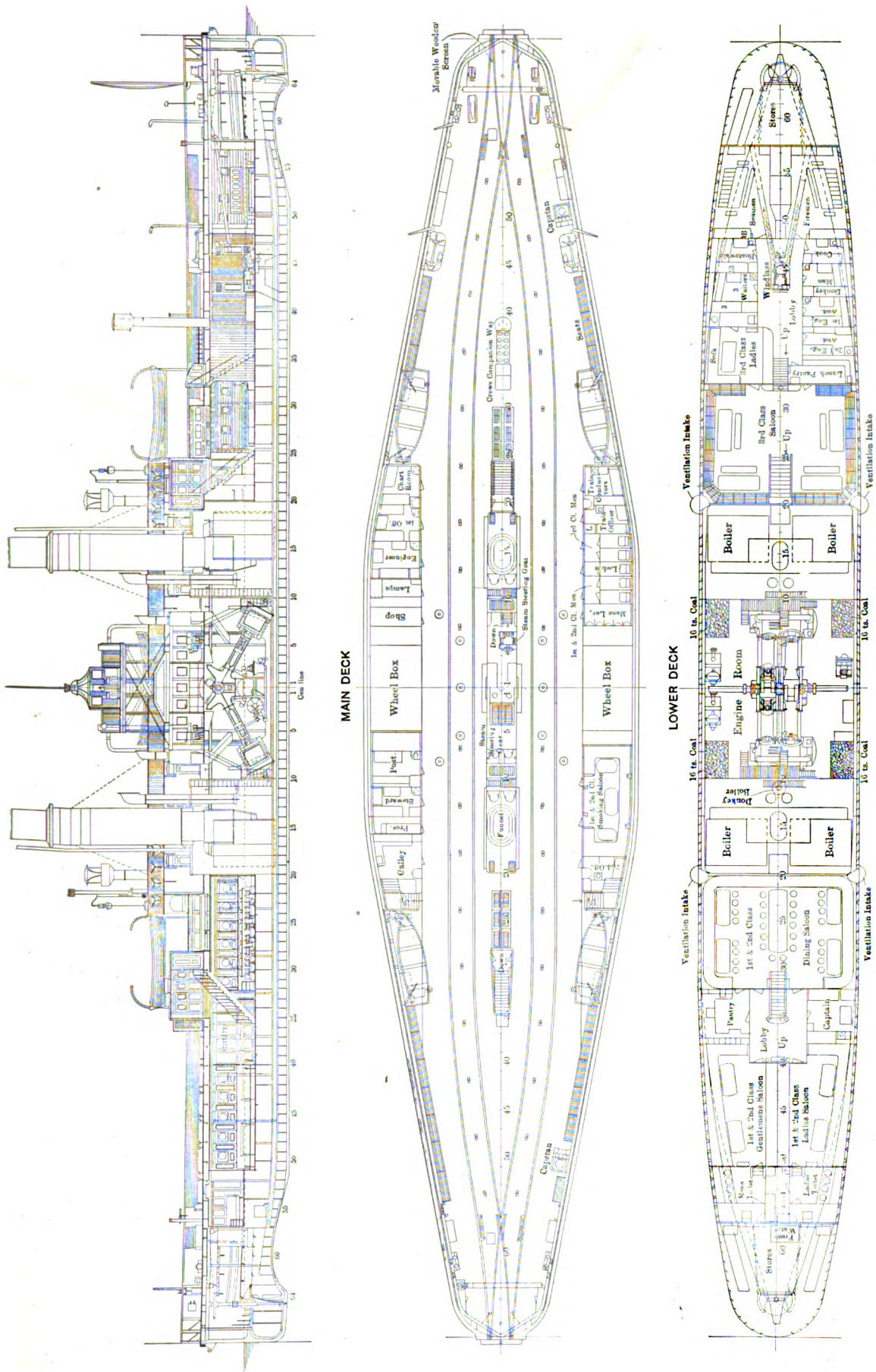


FIG. 9.—PROFILE AND DECK PLANS OF PADDLE-WHEEL FERRY KJOERENHAVN.

Sleeping Accomodation for Passengers without Sleeping Car-tickets

Sleeping Accomodation for Passengers without Sleeping Cart-tickets

LOWER DECK



carried full height clear to the bow, to provide protection against the seas, and the entire fore part is so constructed that it can be raised about an athwartship horizontal axis, forming a sort of portal when raised, and allowing the cars to be shipped under it. The raising and lowering of this part is done by means of worms driven by steam engines underneath the main deck forward. The stopping arrangement at the stern is like that on the other ferries.

The *Jylland*, shown in Fig. 4, is a good type of the ice-breaking ferries used in winter time. She is 184 feet long over all, with a molded beam of 36 feet, a depth of 19 feet 2 inches, and at a draft of 16 feet 4 inches displaces 1,048 tons. Propulsion is by means of a compound engine with cylinders 30 and 57 inches in diameter, with a stroke of 33 inches. At 90 revolutions per minute and a steam pressure of 64 pounds per square inch, the total indicated horsepower is 800. Under these conditions the vessel is capable of maintaining a speed of 11.3 knots. Steam is furnished by two three-furnace single-ended Scotch boilers, having a total heating surface of 3,238 square feet and a grate area of 113 square feet; 1,760 pounds of coal are burned per hour, and the total bunker

capacity is 112 tons, distributed in two wing bunkers and one athwartship bunker. This is a double-track ferry. On the lower deck aft are the first and second class dining saloons,

ladies' cabin and the officers' quarters. Forward, on the same deck, are the third class dining saloon, third class ladies' cabin, crew's and engineers' quarters.

TABLE I.
EXTRACT FROM THE DANISH GOVERNMENT'S RAILROADS.
OFFICIAL ACCOUNT OF THE YEAR 1905-1906.

NAME OF CROSSING.	Date of Opening.	Distance at Crossing Miles.	NUMBER OF DOUBLE TRIPS A YEAR.			NUMBER OF PASSENGERS A YEAR.			TONS OF GOODS CARRIED A YEAR.			Tons of Coal Used, 1905-1906.
			1895-1896.	1900-1901.	1905-1906.	1895-1896.	1900-1901.	1905-1906.	1895-1896.	1900-1901.	1905-1906.	
Fredericia-Strib.....	Mar. 1, 1872.	2.0	7,643	12,577	12,493	230,630	499,200	570,800	149,127	273,843	368,752	3,165.3
Gjedsen-Warnemunde.....	Oct. 1, 1903.	48.0			640*			44,100			53,650	7,300.6
Glyngøere-Nykøbing.....	Oct. 1, 1889.	2.5	1,581	2,182	2,266	35,137	48,200	57,200	13,017	20,090	25,612	959.3
Elsinore-Helsingborg.....	Mar. 10, 1892.	3.0	2,310	3,078	3,456	169,339	287,400	405,600	74,859	95,884	113,051	1,867.8
Copenhagen-Malmoe.....	Oct. 5, 1895.	18.5	329	795	**647	2,627	27,700	**38,000	5,513	123,910	**82,500	3,464.2
Korsør-Nyborg.....	Dec. 1, 1883.	16.0	2,333	4,062	4,243	213,713	496,400	571,000	133,670	280,773	349,240	18,275.7
Madsnedøe-Orehoved.....	Jan. 15, 1884	2.5	2,785	3,740	4,715	98,421	157,900	218,000	44,679	73,934	169,637	2,093.0
Odde-sund.....	June 23, 1883.	2.0	1,999	2,623	2,184	33,486	47,000	55,400	27,777	39,455	51,220	648.2

* Traffic shared with the Mecklenburg Government, only ½ traffic stated here.

** Traffic shared with the Swedish Government, only ½ traffic stated here.

TABLE II.

NAME OF FERRY.	LENGTHS.		BREADTH.		Displacement, Tons.	TONNAGE.		Speed, Knots.	Nos. Boilers.	Nos. Fires.	Heating Surface, Sq. Ft.	Grate Area, Sq. Ft.	Pressure, Lbs. per Sq. In.	Bunker Capacity, Tons.	Lbs. of Coal Burned per Hour.	ENGINES.			Total I.H.P.			
	Over All.	On L.W.L.	Molded.	Over Guards.		Gross.	Net.									No.	Cylinder Diameters, Inches.	Stroke.		Rev. per Min.		
Christian IX.	293' 9"	290' 0"	48' 6"	58' 0"	18' 7"	12' 6"	2,600*	13.0	4	12	7,750	215	185.0	100*	3,325	2	31 1/2	52	82 1/2	63	1,800	
Prinsesse Alexandrine	333' 6"	333' 6"	38' 0"	51' 6"	18' 9"	12' 6"	2,425	13.8	4	12	7,755	215	185.0	130	3,325	2	31 1/2	52	82 1/2	63	2,140	
Prins Christian.	284' 9"	281' 0"	41' 6"	57' 9"	22' 6"	14' 5"	2,065	13.75	4	12	7,557	213	185.0	112	3,740	2	19 3/4	51	52	28	124	2,200
Korsør.	252' 6"	250' 0"	34' 0"	58' 0"	18' 0"	9' 6"	1,267	12.25	4	12	5,290	180	79.5	56	2,640	2	33 1/2	63		54	33	1,200
Nyborg.	253' 6"	250' 0"	34' 0"	58' 0"	18' 0"	9' 6"	1,267	12.25	4	12	5,290	180	79.5	56	2,640	2	33 1/2	63		54	33	1,200
Sjælland.	293' 9"	290' 0"	34' 0"	58' 0"	18' 9"	9' 3"	1,282*	12.5*	4	12	5,190	143	89.5	56	2,860	2	34	62		54	36	1,300
Kjøbenhavn.	278' 0"	272' 0"	34' 0"	58' 0"	18' 9"	10' 0"	1,455	12.5	4	12	5,190	143	89.5	56	2,750	2	34	62		54	36	1,230
Store-Bælt.	278' 6"	272' 6"	34' 6"	58' 0"	18' 9"	10' 4"	1,462	12.5	4	12	5,380	178	89.5	56	2,860	2	34	62		54	34	1,250
Alexandra.	207' 6"	206' 0"	26' 0"	44' 0"	12' 9"	7' 9"	725	10.0	2	4	1,928	64	79.6	21	990	1	32	60		45	38	440
Thyra.	207' 6"	206' 0"	26' 0"	44' 0"	12' 9"	7' 9"	725	10.0	2	4	1,928	64	79.6	32	990	1	32	60		45	38	440
Dagmar.	209' 0"	208' 3"	26' 0"	43' 0"	12' 6"	7' 6"	720*	10.0*	2	4	1,857	59	79.6	30*	880	1	32	60		45	35	380
Strib.	204' 6"	203' 0"	26' 0"	44' 0"	12' 9"	7' 6"	720*	10.0*	2	4	1,919	57	79.6	20*	990	1	29	56		45	35	400
Helsingborg.	180' 0"	177' 0"	32' 0"	43' 0"	14' 6"	10' 3"	720	10.0	2	4	2,497	71	119.4	20	1,210	2	19	38		20	138	630
Kronprinsesse Louise.	209' 0"	206' 0"	26' 0"	44' 0"	12' 9"	8' 6"	665	10.0	2	4	1,929	63	79.6	44	1,012	1	32	60		45	35	420
Kronprins Frederik.	180' 0"	178' 6"	26' 0"	44' 0"	12' 9"	8' 7"	576	10.0	2	4	1,929	63	79.6	21	1,012	1	29	54		45	33	400
Marie.	204' 6"	199' 3"	31' 6"	43' 0"	13' 0"	9' 0"	950*	10.0*	2	6	3,200	93	79.6	45*	1,650	2	21 3/4	36 1/2		18	125	500*
Valdemar.	144' 0"	140' 0"	31' 6"	43' 0"	13' 0"	9' 0"	550	10.0	2	4	2,132	62	79.6	28	1,100	2	21 3/4	36 1/2		18	134	575
Jylland.	184' 0"	180' 0"	36' 0"	48' 0"	19' 2"	16' 4"	1,048	11.3	2	6	3,238	113	64.0	112	1,760	1	30	57		33	90	800
Lille Bælt.	140' 6"	139' 0"	26' 0"	44' 6"	11' 6"	8' 0"	399*	8.0	2	4	1,857	68	25.6	25*	1,100	1	36	36		45	34	280
Fredericia.	140' 6"	138' 6"	26' 0"	44' 6"	11' 6"	7' 3"	390	8.0	2	4	1,857	69	30.0	25*	1,100	1	36 1/2	36 1/2		45	32	280
Hjælmar.	168' 9"	167' 0"	26' 0"	44' 0"	12' 0"	7' 0"	440	10.25	2	4	1,857	59	79.6	21	920	1	32	60		45	37	400
Ingeborg.	168' 9"	167' 0"	26' 0"	44' 0"	12' 0"	7' 0"	440	10.25	2	4	1,857	59	79.6	21	920	1	32	60		45	37	400

TABLE III.

* About.

NAME OF FERRY.	Type.	Where and When Built.	Where Engaged.
Christian IX.	Twin screw, double track.	Burmester & Wain, Copenhagen, 1908.	Korsør-Nyborg.
Prins. Alexandrine	Paddle wheel, double track.	Schichau's Yard, Elbing, 1903.	Gjedsen - Warnemunde.
Prins Christian.	Twin screw, double track.	Elsinore's Shipyard, 1903.	Gjedsen - Warnemunde.
Korsør.	Paddle wheel, double track.	Kochum's Yard, Malmoe, 1883.	Korsør-Nyborg.
Nyborg.	Paddle wheel, double track.	Kochum's Yard, Malmoe, 1883.	Korsør-Nyborg.
Sjælland.	Paddle wheel, double track.	B. & W., Copenhagen, 1887.	Korsør-Nyborg.
Kjøbenhavn.	Paddle wheel, double track.	B. & W., Copenhagen, 1895.	Copenhagen-Malmoe.
Store-Bælt.	Paddle wheel, double track.	B. & W., Copenhagen, 1900.	Korsør-Nyborg.
Alexandra.	Paddle wheel, single track.	B. & W., Copenhagen, 1892.	Madsnedøe - Orehoved.
Thyra.	Paddle wheel, single track.	B. & W., Copenhagen, 1893.	Madsnedøe - Orehoved.
Dagmar.	Paddle wheel, single track.	B. & W., Copenhagen, 1889.	Madsnedøe - Orehoved.
Strib.	Paddle wheel, single track.	Elsinore, 1901.	Fredericia-Strib.
Helsingborg.	Single F. and aft screw, single track.	Elsinore, 1902.	Elsinore - Helsingborg.
Kronprinsesse Louise.	Paddle wheel, single track.	Elsinore, 1891.	Elsinore - Helsingborg.
Kronprins Frederik.	Paddle wheel, single track.	Elsinore, 1898.	Elsinore - Helsingborg.
Marie.	2 screws aft, 1 screw forward, single track.	B. & W., Copenhagen, 1890.	Madsnedøe - Orehoved.
Valdemar.	single screw, single track, icebreaker.	B. & W., Copenhagen, 1886.	Reserve.
Jylland.	single screw, single track, icebreaker.	B. & W., Copenhagen, 1894.	Reserve.
Lille Bælt.	Paddle wheel, single track.	Richardson, Newcastle, 1872.	Fredericia-Strib.
Fredericia.	Paddle wheel, single track.	Shichau, Elbing, 1877.	Fredericia-Strib.
Hjælmar.	Paddle wheel, single track.	Shichau, Elbing, 1883.	Glyngøere - Nykøbing.
Ingeborg.	Paddle wheel, single track.	Shichau, Elbing, 1883.	Odde-sund.

THE RIVETED JOINTS OF CYLINDRICAL BOILERS.

BY H. K. SPENCER, CHIEF ENGINEER U. S. R. C. S.

Assume that the diameter of the boiler shell has been determined and the quality of the material to be used in its construction has been selected, and all the necessary data are at hand for designing the riveted joints of the boiler. Only those joints commonly used in cylindrical boilers will be discussed; they are the single, double and triple riveted lap joints, and the double and triple riveted, double butt-strapped butt joints.

Let

 P = working pressure in pounds per square inch,

 R = inside radius of cylindrical shell in inches,

 t = thickness of shell in inches, and

 T = tensile strength of material in pounds per square inch of section.

The total pressure tending to burst the cylindrical shell of the boiler longitudinally is, if the length of the shell is 1 inch, $2 \times R \times 1 \times P$, which is resisted by two sections of metal each 1 inch long and t inch thick, having a tensile strength T pounds per square inch, so the equation can be written,

$$2 \times R \times 1 \times P = 2 \times 1 \times t \times T, \text{ and } R P = T t. \dots (1.)$$

The pressure tending to tear the shell apart circumferentially is $P \pi R^2$, which is resisted by a section of metal of $2 \pi (R + 1/2t) T$ square inch, so $P \pi R^2 = 2 \pi (R + 1/2t) T$, and $R P = 2t T (1 + t/2R) \dots (2.)$, from which it is seen that a boiler is a little more than twice as strong circumferentially as it is longitudinally.

To obtain the maximum economy of material in a riveted joint it should be so proportioned that it will be no more liable to rupture by the tearing apart of the plate than by the shearing of the rivets, or by the failure of the plate or rivets by crushing. In lap joints and butt joints with single butt straps the rivets are in single shear, while in butt joints with double butt straps they are in double shear. The shearing strength of rivet steel is about 0.8 of its tensile strength, and the strength of a rivet in double shear is considered to be 1.8 times the strength of the same rivet in single shear. Steel is used almost entirely for boiler construction.

$T = 60,000$ pounds per square inch,

$S = 48,000$ pounds per square inch, shearing strength of rivets, and

$C = 66,000$ pounds per square inch, strength of plate and rivets in compression.

A factor of safety of 4.5 is sufficient to insure bringing the working strength well within the elastic limit of the material.

Equation (1.) shows that the strength, longitudinally, of a plain cylindrical shell to resist a bursting pressure is independent of its length, so a girth strip of length equal to the pitch of the rivets can be considered. Let

p = the pitch of the rivets in inches, and
 d = the diameter of the rivets in inches.

From equation (1.), the strength, longitudinally, of a cylindrical shell, made with a perfectly welded joint, is expressed by

$$p R P = T p t, \text{ and } t = R P / T \dots \dots \dots (3.)$$

Any riveted joint is weaker than the plate, because a certain amount of the material of the plate must be cut out for the line of rivets, so the thickness must be greater than that of the cylindrical shell, perfectly welded.

SINGLE LAP RIVETING.

The single riveted lap joint is the simplest, but it is never used except for joints exposed to the fire, where tightness only is essential in the seam, and for the girth seams of boilers of small diameter, for moderate working pressures. To show the low efficiency of this style of joint, suppose the longitudinal seam of a boiler to be a single riveted lap joint. The inside diameter of the shell is taken as 72 inches, and the working pressure as 80 pounds per square inch. Referring to Fig. (1.), and considering a ring of width (p), it is seen that the plate, at the line of rivets, has a section of $(p - d)$ square inch and the strength of the shell, in tension, then is, from equation (1.),

$$p R P = 60,000 (p - d) t \dots \dots \dots (4.),$$

and the strength to resist shearing is

$$p R P = 48,000 \pi d^2 / 4 \dots \dots \dots (5.),$$

and the resistance to crushing is, taking the projected area of the rivet as the area of rivet and plate in compression,

$$p R P = 66,000 d t \dots \dots \dots (6.)$$

It is seen that all these expressions are equal, therefore, combining (4) and (6) gives

$$60,000 (p - d) t = 66,000 d t, \text{ and } p = 2.1 d \dots \dots (7.)$$

The efficiency of the joint is

$$[(p - d) / p] \times 100 = [(2.1d - d) / 2.1d] \times 100 = 52.38 \text{ percent.}$$

Combining (5) and (6) gives

$$48,000 \pi d^2 / 4 = 66,000 d t, \text{ and } t = 0.5712 d \dots \dots (8.)$$

For the 72-inch boiler, the value of d can be found from equation (6) by substituting in it the values of p from (7), and t from (8), and the known quantities R and P , and introducing the factor of safety, 4.5. Then

$$2.1 d \times 36 \times 80 = (66,000 / 4.5) \times 0.5712 d^2.$$

$$d = 0.7219 \text{ inch.}$$

$$t = 0.5712 d = 0.4124 \text{ inch.}$$

$$p = 2.1 d = 1.516 \text{ inch.}$$

DOUBLE LAP RIVETING.

The double-riveted lap joint is frequently used for the longitudinal seams of boilers of small diameter and moderate working pressures and for the girth seams of large boilers to carry high pressures. For comparison with the single riveted lap joint, suppose the longitudinal seam of the boiler under consideration to be a double-riveted lap joint. The riveting may be arranged either as in Fig. 2, called chain riveting, or as in Fig. 3, called staggered or zigzag riveting; the latter is gen-

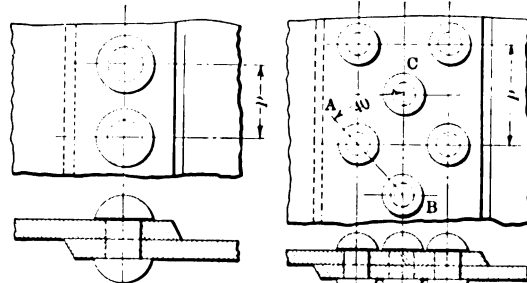


Fig. 1

Fig. 4

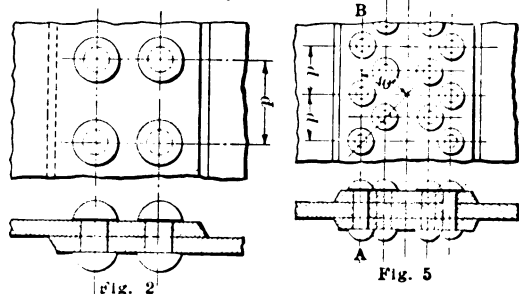


Fig. 2

Fig. 5

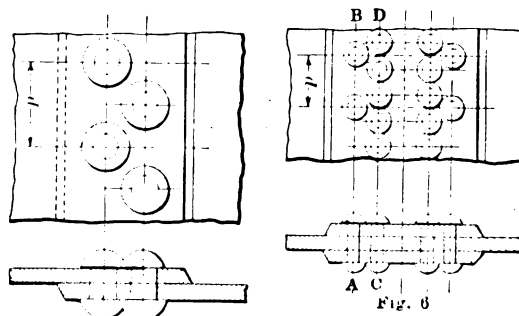


Fig. 3

Fig. 6

LAP AND BUTT JOINTS.

erally used, as it gives the same strength as chain riveting, with less material in the lap.

As before, consider a ring of width equal to the pitch of the rivets. For tensile strength, equation (4) is used unmodified, and $p R P = 60,000 (p - d) t$.

In this joint there are two rivets to take the shearing and crushing stresses, so equations (5) and (6) are modified, respectively, to

$$p R P = 48,000 \times 2 \pi d^2 / 4 \dots \dots \dots (9.)$$

$$p R P = 66,000 \times 2 d t \dots \dots \dots (10.)$$

Combining (4) and (10) gives

$$60,000 (p - d) t = 66,000 \times 2 d t, \text{ and } p = 3.2 d \dots \dots (11.)$$

The efficiency is $(3.2d - d) / 3.2d \times 100 = 68.75$ percent.

Similarly, combining (9) and (10) gives

$$48,000 \times 2 \pi d^2 / 4 = 66,000 \times 2 d t, \text{ and } t = 0.5712 d \dots \dots (12.)$$

Substituting the values of p and t , as given by equations (11) and (12), in equation (10) gives, using, as before, a

factor of safety of 4.5, $3.2d \times 36 \times 80 = (66,000 / 4.5) \times 2 \times 0.5712 d^2$, and
 $d = 0.5504$ inch,
 $t = 0.5712 d = 0.3142$ inch,
 $p = 3.2 d = 1.763$ inch.

TRIPLE LAP RIVETING.

In a triple-riveted lap joint, Fig. 4, there are three rivets in single shear, and three to take the crushing stress, so the equations for this style of joint are as follows: Equation (4),

$$\begin{aligned} p R P &= 60,000 (p - d) t, \\ p R P &= 48,000 \times 3\pi d^2 / 4 \dots\dots\dots (13.) \\ p R P &= 66,000 \times 3 d t \dots\dots\dots (14.) \end{aligned}$$

combining (4) and (14) gives $p = 4.3 d \dots\dots\dots (15.)$

The efficiency is $[(4.3d - d) / 4.3d] \times 100 = 76.74$ percent.

Combining (13) and (14) gives $t = 0.5712 d \dots\dots (16.)$

Substituting the values of p and t , as given by (15) and (16), in (14), introducing the factor of safety, 4.5, and the values of R and P , as used before, gives

$$\begin{aligned} d &= 0.4927 \text{ inch,} \\ t &= 0.5712 d = 0.2815 \text{ inch,} \\ p &= 4.3 d = 2.119 \text{ inches.} \end{aligned}$$

In staggered riveting, the distance between the rows of rivets must be such that the plate will not tear obliquely between the rivets. Here the metal is subjected to a combined tension and shearing stress. By making the angle ABC , Fig. 3, about 40 degrees, sufficient strength is given and the distance between rows of rivets is about $0.42 p$, as a minimum.

BUTT JOINTS.

For butt joints with single butt straps the same diameter of rivets, thickness of plate and pitch of rivets would be obtained as with lap riveting, though double the number of rivets would be used. The butt strap should be the same thickness as the plate.

DOUBLE BUTT STRAPS, DOUBLE RIVETING.

A double-riveted butt joint, with double butt straps, is shown in Fig. 5. Such seams can be used for the longitudinal seams of boilers of small diameter for moderate working pressures. It will be considered as applied to the 72-inch boiler for 80 pounds pressure, for comparison with the double-riveted lap joint.

It is evident that the section of plate along the line AB is the one to be considered in calculating the tensile strength, and the section of plate in tension is $(p - d) t$. Each rivet presents two sections to resist shearing. Putting the shearing strength equal to the crushing strength gives an equation similar to (12), but in this case the rivets are in double shear, and hence have a value 1.8 times that given by (12), and

$$t = 0.5712 d \times 1.8 = 1.028 d \dots\dots\dots (17.)$$

As was done with the lap joints, the tensile strength of the plate section can be placed equal to the strength of the rivets or plate in compression, and equations (4) and (10) hold true here, so $p = 3.2 d$, and the efficiency is the same as for double lap riveting, 68.75 percent.

Substituting as before, and using the same factor of safety, gives $3.2 d \times 36 \times 80 = (66,000 / 4.5) \times 2 \times 1.028 d^2$, and

$$\begin{aligned} d &= 0.3056 \text{ inch,} \\ t &= 0.3142 \text{ inch,} \\ p &= 0.9778 \text{ inch.} \end{aligned}$$

It is seen that, while this joint gives the same efficiency and thickness of plate as the double-riveted lap joint, it gives a different proportion of rivet diameter to plate thickness. For strength alone the butt straps need be only one-half as thick as

the plates, but for tightness and rigidity they are made equal to three-fourths of, or to the plate thickness. The angle ABC must not be less than 40 degrees.

The double-riveted, double but strapped joint, when used, should be made as in Fig. 6, with alternate rivets in the outer rows omitted. In this joint the pitch is taken as the distance between centers of the outer rivet holes; that is, along the line AB . The tendency to rupture must be no greater along the line CD than along the line AB . The section of plate at AB , to resist tension, is $(p - d) t$, and its strength is expressed by equation (4), while that along CD is $(p - 2d) t$, but the weaker section at CD is compensated for by the rivet sections in the outer row, which must be sheared by the bursting pressure, in addition to tearing the plate along the line CD . The total resistance to rupture along that line is expressed by the equation

$$p R P = 60,000 (p - 2d) t + 48,000 \times 1.8\pi d^2 / 4. \quad (18.)$$

For shearing, the strength is expressed by

$$p R P = 48,000 \times 3 \times 1.8\pi d^2 / 4 \dots\dots\dots (19.)$$

For compression, the equation is the same as (14).

As all these expressions are equal,

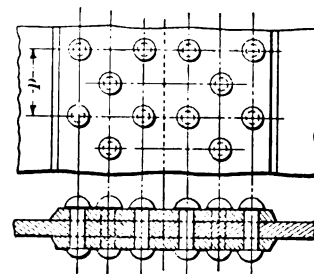


Fig. 7

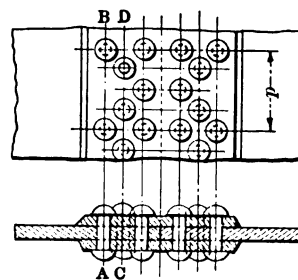


Fig. 8

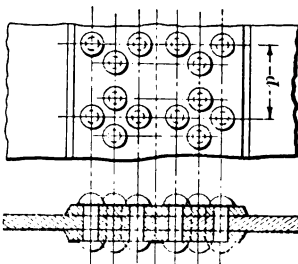


Fig. 9

$$\begin{aligned} 60,000 (p - 2d) t + 48,000 \times 1.8\pi d^2 / 4 &= 60,000 (p - d) t, \text{ which, rewritten, expresses the condition} \\ \text{for equal strength along } AB \text{ and } CD \text{ as } 60,000 d t &= 48,000 \times 1.8\pi d^2 / 4 \dots\dots\dots (20.) \\ t &= 1.131 d \dots\dots\dots (21.) \end{aligned}$$

Equation (20) shows that the rivets in the outer rows must have a shearing strength equal to the amount by which the tensile strength of the plate at the inner row is reduced, by the additional rivet hole in that row.

Putting the tensile strength equal to the crushing strength, $60,000 (p - d) t = 66,000 \times 3 d t$, and

$$p = 4.3 d \dots\dots\dots (22.)$$

The efficiency of the joint is the same as for the triple-riveted lap joint, 76.74 percent.

This style of joint is used for the longitudinal seams of boilers for moderately high working pressures. Suppose it to be used in a 72-inch boiler to carry 80 pounds pressure, then, using a factor of safety of 4.5,

$$\begin{aligned}d &= 0.2489 \text{ inch,} \\t &= 0.2815 \text{ inch.} \\p &= 1.071 \text{ inches.}\end{aligned}$$

For a 12-foot boiler, to carry 120 pounds pressure,

$$\begin{aligned}d &= 0.7466 \text{ inch,} \\t &= 0.8444 \text{ inch,} \\p &= 3.197 \text{ inches.}\end{aligned}$$

For a boiler 14 feet inside diameter, to carry 160 pounds,

$$\begin{aligned}d &= 1.161 \text{ inch,} \\t &= 1.314 \text{ inch,} \\p &= 4.994 \text{ inches.}\end{aligned}$$

DOUBLE BUTT STRAPS, TRIPLE RIVETING.

Fig. 7 shows a triple-riveted, double butt strapped joint. Each section of width p presents three rivets in double shear to resist the shearing stress, and three to withstand crushing. Putting the tensile strength equal to the crushing strength gives $60,000 (p - d) t = 66,000 \times 3 d t$, from which,

$$p = 4.3 d \dots\dots\dots (23.)$$

The efficiency is 76.74 percent.

There being three rivets in double shear, the proportion of t to d is the same as that expressed by equation (17), and $t = 1.028 d \dots\dots\dots (24.)$

For the 14-foot boiler for 160 pounds working pressure, the results are

$$\begin{aligned}d &= 1.278 \text{ inches,} \\t &= 1.314 \text{ inches,} \\p &= 5.497 \text{ inches.}\end{aligned}$$

The efficiency and thickness of plate are the same as obtained with triple lap riveting and double butt riveting, omitting alternate rivets in the outer rows.

The triple-riveted, double butt strapped joint, when used for boilers to carry high pressures, is made with the alternate rivets in the outer rows omitted, as in Fig. 8. The pitch is taken as the distance between centers of rivets in the outer rows. Here for each pitch there are five rivets in double shear, and five to resist crushing. The joint must not be more liable to fail along CD than along AB , so here again the condition must be $60,000 d t = 48,000 \times 1.8 \pi d^2/4$, and $t = 1.131 d \dots\dots\dots (25.)$

Equations, one similar to that from which (23) was derived, expressing equal strength along AB and CD , and one giving the strength in compression, can be written, and

$$\begin{aligned}60,000 (p - 2d) t + 48,000 \times 1.8 \pi d^2/4 &= 60,000 (p - d) t \\&= 66,000 \times 5 d t, \text{ and } p = 6.5 d \dots\dots\dots (26.)\end{aligned}$$

The efficiency is 84.61 percent.

For a boiler 14 feet in diameter, to carry 160 pounds pressure,

$$\begin{aligned}d &= 1.053 \text{ inches,} \\t &= 1.191 \text{ inches,} \\p &= 6.846 \text{ inches.}\end{aligned}$$

The triple-riveted joint is sometimes made, as in Fig. 9, with not only the alternate rivets in the outer rows omitted, but also the alternate ones in the inner rows. The condition, $60,000 d t = 48,000 \times 1.8 \pi d^2/4$, must also be kept here, and again, $t = 1.131 d$.

There are four rivets in double shear and four in compression for each pitch, and $p = 5.4 d$. The efficiency is 81.48 percent.

For the 14-foot boiler,

$$d = 1.094 \text{ inches,}$$

$$t = 1.237 \text{ inches,}$$

$$p = 5.907 \text{ inches.}$$

The most efficient triple-riveted butt seam is obtained by the arrangement of rivets shown in Fig. 10, where the number of rivets per pitch is reduced by one in each row, outward from the butt. Here again the condition must be kept, that $60,000 d t = 48,000 \times 1.8 \pi d^2/4$, and $t = 1.131 d$.

There are six rivets in double shear and six in compression in each strip of width p , which is the distance between rivet centers in the outermost row, and $p = 7.6 d$, which makes the efficiency 86.84 percent.

For a 14-foot boiler, to carry 160 pounds,

$$\begin{aligned}d &= 1.003 \text{ inches,} \\t &= 1.134 \text{ inches,} \\p &= 7.622 \text{ inches.}\end{aligned}$$

A form of triple-riveted butt joint is shown in Fig. 11. It is used for the longitudinal seams of locomotive boilers which have diameters as large as 84 inches and carry pressures up to 220 pounds per square inch. It is seen that in each strip of width p , which is taken as the distance between rivet centers in the outermost rows, there are four rivets in double shear and one in single shear, and that there are five rivets to resist crushing. The resistance to rupture along CD must equal that along AB ; that is, the tensile strength of the plate at CD , plus the strength of the rivets in the outermost row in single shear, must be equal to the tensile strength of the plate along AB , or algebraically, $60,000 (p - 2d) t + 48,000 \pi d^2/4 = 60,000 (p - d) t$, which imposes the condition, $60,000 d t = 48,000 \pi d^2/4$, and $t = 0.6283 d \dots\dots\dots (27.)$

For equal strength to resist tearing, at AB or CD , shearing and compression, the equations can be written,

$$\begin{aligned}60,000 (p - 2d) t + 48,000 \pi d^2/4 &= 60,000 (p - d) t \\&= 66,000 \times 5 d t, \text{ and } p = 6.5 d \dots\dots\dots (28.)\end{aligned}$$

The efficiency is 84.61 percent, the same as for the joint shown in Fig. 8.

For a 14-foot boiler for 160 pounds working pressure,

$$\begin{aligned}d &= 1.896 \text{ inches,} \\t &= 1.191 \text{ inches,} \\p &= 12.32 \text{ inches.}\end{aligned}$$

For a locomotive boiler 78 inches inside diameter, to carry a working pressure of 200 pounds, the results are

$$\begin{aligned}d &= 1.103 \text{ inches,} \\t &= 0.693 \text{ inch,} \\p &= 7.169 \text{ inches.}\end{aligned}$$

From equations (25) and (26), for the same boiler,

$$\begin{aligned}d &= 0.613 \text{ inch,} \\t &= 0.693 \text{ inch,} \\p &= 3.983 \text{ inches,}\end{aligned}$$

and, if made as in Fig. 10,

$$\begin{aligned}d &= 0.5957 \text{ inch,} \\t &= 0.6737 \text{ inch,} \\p &= 4.527 \text{ inches.}\end{aligned}$$

Made as in Fig. 11, with the narrow butt strap outside, a good calking edge is presented, with the minimum distance between rivets, so the arrangement not only gives high efficiency, but insures tightness, where comparatively thin plates are used. It is seen that such riveting would be impracticable for boilers of large diameters, for high pressures, because of the large diameter of rivet necessary.

Figs. 1 to 6, inclusive, are drawn to the same scale and show the results obtained by applying the different styles of riveting to a boiler 72 inches in diameter to carry 80 pounds pressure. Figs. 7 to 11, inclusive, are also drawn to the same scale, and are calculated for the 14-foot boiler. For convenient comparison, the results obtained by applying the different styles of riveting, as shown by Figs. 6 to 11, inclusive, to the longitudinal seams of a 14-foot boiler to carry a working

pressure of 160 pounds, are tabulated below. $2n$ = number of rivets per pitch. N = number of rivets in a seam 10 feet long. E = efficiency, percent.

FIGURE.	d .	t .	p .	$2n$.	N .	E .
6	1.161	1.314	4.994	6	144	76.74
7	1.278	1.314	5.497	6	132	76.74
8	1.053	1.191	6.846	10	176	84.61
9	1.094	1.237	6.907	8	164	81.48
10	1.003	1.134	7.622	12	190	86.84
11	1.896	1.191	12.32	10	98	84.61

If, instead of using the riveting shown in Fig. 7 for the 14-foot boiler, that shown in Fig. 8 was used, a saving of 2,360 pounds in the weight of the shell would result, by using that shown in Fig. 9, 1,480 pounds, and by using that shown in Fig. 10, 3,450 pounds.

In general, it may be said that the efficiency of the double butt strapped joint can be indefinitely increased by increasing the number of rows of rivets, while decreasing the number of rivets in each row by one, outward from the butt of the plates.

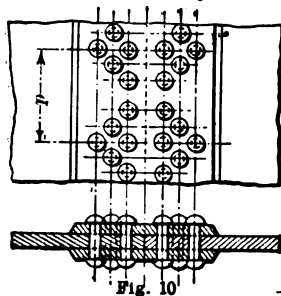


Fig. 10

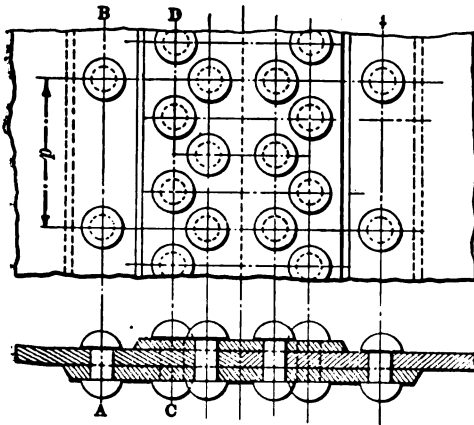


Fig. 11

Then, if the condition, $S \times 1.8\pi d^3/4 = T d t$, is maintained, the joint will be equally strong along each row of rivets, and the section plate at the outer row of rivets is the measure of the efficiency.

GENERAL RULES.

A quality of material, giving different values of T , S and C than those assumed by the writer, would often be used, so general expressions for t and p , in terms of d , are given. Let n equal one-half the number of rivets in a girth strip of width equal to the pitch.

For lap joints,

$$t = 0.7854 d S/C, \text{ or } d = 1.273 t C/S \dots (29.)$$

$$p = (Cn - T)d/T \dots (30.)$$

For butt joints with double straps, all rivets in double shear,

$$t = 1.414 d S/C, \text{ or } d = 0.8903 t C/S \dots (31.)$$

For double butt joints all rivets in double shear and alternate rivets in the outer rows omitted,

$$t = 1.414 d S/T, \text{ or } d = 0.8903 t T/S \dots (32.)$$

If the rivets in the outer rows are in single shear,

$$t = 0.7854 d S/T, \text{ or } d = 1.273 t T/S \dots (33.)$$

For the last three cases, the general expressions for the relations of p to d are the same as (30).

An extra 1/16 inch is usually added to the thickness of plate found by the formulæ, as an allowance for corrosion, so the designed pressure may be carried until the plates have lost that much in thickness.

GIRTH SEAMS.

The pressure acting to tear the boiler apart circumferentially is $P R$. Equations (1) and (2) show that the shell itself, as designed for strength longitudinally, is twice as strong as need be to resist rupture circumferentially, so, in the girth seams, the shearing strength of the rivets is all that need be considered. Assuming that the rivets in the girth seams are the same size as those in the longitudinal seams, and calling the total number of rivets in the seam (n_1), the equation for their shearing strength is

$$P\pi R^2 = (48,000/4.5) \times n_1 \pi d^2/4, \text{ and } n_1 = 3 P R^2/8,000 d. (34.)$$

The length of the seam to be riveted is $2\pi (R + t)$ inches, so, if n_2 is the number of rows of rivets in the seam, the pitch of the rivets will be

$$p_1 = 2\pi n_2 (R + t) / n_1 \dots (35.)$$

For a boiler 14 feet in diameter, to carry a working pressure of 160 pounds, $d = 1.053$ inches for the longitudinal riveting, if as in Fig. 8, and $n_1 = 382$, and then, from (35), using the proper value of t , $p_1 = 2.804$ inches, the girth seams being double-riveted lap joints.

CENTER OF RIVET TO EDGE OF PLATE.

In all riveting, the distance from the center of the rivet hole to the edge of the plate must be such that the plate in front of the rivet will not fail, as in Fig. 12, by tearing apart, and also there must be no possibility that the metal will shear out along the lines ab and cd . The latter will not occur in lap joints when $2 l_1 t S$ is greater than $\pi d^2 S/4$, or in double-strapped butt joints when $2 l_1 t S$ is greater than $1.8\pi d^2 s/4$.

The metal directly in front of the rivet is subjected to a stress similar to that of a beam fixed horizontally at both ends,

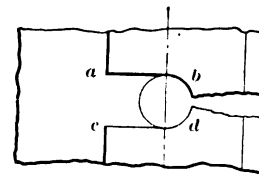


Fig. 12.

and loaded in the middle. The length of the beam is d , the diameter of the rivet; its depth is $l_1 - 1/2 d$, and its breadth is t . The load, which will be called P_1 , is that tending to shear one rivet, and is equal to the load tending to rupture a ring of the shell of width equal to the pitch, so, if n is taken to represent the number of rivets in a lap joint, or one-half the number in a butt joint, for each strip of width p , $P_1 = p R P/n$. (36.)

From the equation for safe loading for a beam fixed horizontally at both ends, with a single load in the middle, calling the ratio, $t/d = n_3$, $l_1 = d/2 + \sqrt{P_1/16,000 n} \dots (37.)$ or, substituting the value of (P_1),

$$l_1 = d/2 + \sqrt{p R P/16,000 n n_3} \dots (38.)$$

For the 14-foot boiler, with riveting as in Fig. 8, $d = 1.053$ inches, $t/d = 1.131$, $p = 6.846$ inches, and, substituting these values in (38), $l_1 = 1.52$ inches.

In calculating the stays for the flat surfaces in a boiler, it is not considered that the material in the surface supported has

any value in resisting the bursting pressure. Whenever possible the stays should be so spaced as to permit a man to pass between them; this can always be done with the through braces above the tubes, where the plates can be reinforced by large washers riveted to the plates supported. Here the pitch is seldom greater than 16 inches. Calling the pitch of the stays p_2 , the load each stay supports is $p_2 \times P$, P being the boiler pressure. Each square inch of net section of the stay should safely support a working load of 10,000 pounds (working stress allowed by Lloyds), so, calling the diameter of the stay d_2 , the equation for its strength is

$$p_2^2 P = 10,000 \pi d_2^2 / 4, \text{ and } d_2 = .0113 p_2 \sqrt{P} \dots (39.)$$

Let $p_2 = 16$ inches and $P = 160$ pounds, then $d_2 = 2.279$ inches.

The fire surfaces of a boiler have a thickness of $\frac{1}{2}$ inch to $\frac{5}{8}$ inch, and the plate cannot be reinforced with washers, so the strength of the square of plate supported by four stay bolts is considered. Its support is such that the square of plate can be considered as a beam fixed horizontally at both ends, and the load uniformly distributed over the whole upper surface. Call the pitch of the stay bolts p_1 and the thickness of

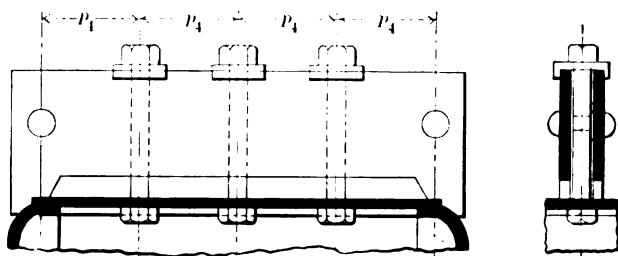


FIG. 13.

the plates t_1 , then, from the formula for the safe loading of a beam fixed horizontally and uniformly loaded,

$$p_1 = 155 t_1 \sqrt{1/P} \dots (40.)$$

where P is the boiler pressure.

Applying the above to a boiler with $\frac{1}{2}$ -inch sheets in the back connection, to carry 160 pounds working pressure, gives $p_1 = 6.13$ inches.

Allowing these stay bolts a safe working load of 8,000 pounds per square inch of net section, as allowed by Lloyds for such stays, their diameter is

$$d = .0127 p_1 \sqrt{P} \dots (41.)$$

Let $p_1 = 6.13$ inches, and $P = 160$ pounds, then $d_1 = 0.9845$ inch.

The top sheet of the combustion chamber must be supported by stays, but here it is not practicable to stay one sheet to another, so these stays are carried on girders, bridging the top of the fire-box from the back-tube sheet to the back sheet of the combustion chamber. The depth of the combustion chamber is generally such that three stays placed equally distant from the ends of the girders, and from each other, will give a proper pitch for them. The girder is in the condition of a beam supported at the ends and loaded with three loads symmetrically placed. It is made of a pair of plates separated by distance pieces slightly more than the diameter of the stays, and held together by rivets somewhat as in Fig. 13.

Let p_1 be the pitch of the stay bolts along the girder, and p_2 the pitch of the girders. The load on each stay is $P \times p_1 \times p_2$. Let h be the depth of the girder and b the thickness of one plate of the girder, then, from the equation for safe loading for such girder,

$$h = \sqrt{\frac{P (p_1 p_2 - l_2 p_1 p_2)}{12,000 b}} \dots (42.)$$

where l_2 is the distance in inches between supports.

$$\text{Very often } l_2 = 4 p_2, \text{ then } h = .0316 p_2 \sqrt{\frac{p_1 P}{b}} \dots (43.)$$

By making $b = 1/10 p_2$, which gives a good proportion of thickness of plate to depth of girder, $h = 1 p_2 \sqrt{P} \dots (44.)$

Assume, for a boiler to carry 160 pounds, that l_2 equals 24 inches, $p_2 = 7$ inches, and $b = 1/10 p_2 = 0.7$ inch, then from equation (44) $h = 7.59$ inches.

THE TWIN-SCREW SHIP LADY FRASER.

There was launched March 1, from the yard of the Fairfield Shipbuilding & Engineering Company, Ltd., the pilot cruiser *Lady Fraser*, which has been specially built for the service of the Indian government. She is a twin-screw vessel, length 301 feet 6 inches, breadth 38 feet, and depth 21 feet, with a speed of 12½ knots; schooner-rigged, having three pole masts specially high for signaling purposes, and fitted for wireless telegraphy. A special feature is the pilot's pinnace, which is placed on chocks between the main and mizzen masts, and a most efficient arrangement has been made for the rapid handling of this boat, which has to be unshipped at sea with the pilots on board, four steam winches being provided for this purpose.

Under the forward end of the bridge deck there is situated a large, well-lighted and handsomely decorated saloon for the use of the pilots as a reading and smoking room. This may be transformed into a dining saloon when desired. There is also an elegantly furnished suite of staterooms and bath room for the use of the government officials, and abaft these rooms is the accommodation for the ship's officers, each having a separate cabin. The captain's cabin, combined with the chart room, is arranged under the bridge. Commodious accommodation for the pilots, twenty-six in number, is arranged on the lower deck, forward, where two large dining tables, with revolving chairs, are fitted. The pilots are berthed in swinging cots, which are unshipped and stowed in racks when not in use. The leadsmen's quarters, fitted up to accommodate ten persons, is on the lower deck, immediately abaft the engine room, and aft of this again, and separated by a steel bulkhead, is the crew's quarters.

The native crew, including deck hands, firemen, servants, etc., numbering about fifty, as well as the leadsmen, sleep in hammocks, and their quarters are spacious and well ventilated.

The crew's washhouses, etc., are located on the upper deck, aft.

Cold chambers for preserving meat and vegetables are fitted on the platform deck under the crew's quarters, with access by means of a trunk from the bridge deck. These compartments are efficiently insulated with granulated cork, and cooled with brine led from the refrigerating machine, which is placed at the after end of the engine room. Brine is also led to the thermotanks on the upper deck, which supply cold air to the officers' and pilots' quarters, this being regulated by means of louvres in each compartment. Special attention has been given to the natural ventilation of the vessel, which is most efficient throughout; portable electric fans are fitted in the staterooms, pilots' quarters, smoking room and engineers' mess. There is also a complete installation of electric lights.

The propelling machinery consists of two triple-expansion surface-condensing engines, each having three inverted cylinders working on three cranks. The high-pressure and intermediate-pressure cylinders are each fitted with a piston valve, and each low-pressure cylinder with a single ported slide valve, all the valves being worked by the usual double eccentric and link-motion valve gear. The crankshaft is in

three pieces, each piece being built and interchangeable, and, together with the thrust, tunnel, and propeller shafts, is of forged mild steel. Each screw propeller has three blades of bronze.

The condensers are separate from the main engines, built of steel boiler plates and galvanized, the condensing water being supplied by two large centrifugal pumps, one for each condenser, each worked by an independent steam engine, and each capable of supplying circulating water to either condenser in the event of one pump being disabled. Both circulating pumps will be connected to large valves leading to the bilges, so that in case of need these pumps could be utilized in pumping out the engine room.

There are two boilers, of the multitubular marine type, to work with natural draft, constructed entirely of steel and adapted for a working pressure of 200 pounds per square inch.

BUILDING A HARBOR.

BY CHARLES F. HOLDER.

In following along the shore line of California, one is impressed with the fact that in the 600 or more miles of sea coast, from San Diego to San Francisco, there are but two good harbors. Both are at the extremes. San Diego Bay is a fine, natural harbor, as is also San Francisco Bay; but between these two the harbors are not worthy the name, and in the East would be termed open roadsteads. Monterey Bay affords some protection, but Hueneme, Fort Harford, Santa Monica, Redondo, Ventura and Newport are open roads, from which all vessels are obliged to flee in case of bad storms.

Long Beach and at other points. For many years attempts have been made to secure a large government appropriation for a harbor at some point, but owing to local jealousies the end wished for has invariably been defeated. Various boards have been appointed by the government to report upon a suitable site, and with remarkable unanimity they have reported on San Pedro. But the Southern Pacific Railroad—a strong factor—took the field in favor of Santa Monica, and so the matter has been delayed until within a year or two, when a final board reported again in favor of San Pedro, and the work began—perhaps the largest contract of the kind ever given in America; certainly the largest on the Pacific Coast.

The location selected has this advantage: that it already has a good harbor, affording protection and wharfing to full-rigged ships and to the largest Pacific coastwise steamers. The entrance and the inner harbor is shown in Fig. 1. The location was originally a lagoon, formed by Dead Man's Island; but by breakwaters it has been changed into a small but good harbor of refuge, the narrow entrance leading to an inner bay of large extent, which can readily be dredged and made a good harbor for a large fleet. But the plan at present is to form an outer harbor, and to this end the government advertised for bids for work on a breakwater of stone, which should be built across the field of the prevailing wind. The breakwater was to be 8,500 feet in length, which it was estimated would provide an area of quiet water equal to 1 square mile. The nature of the work can be imagined when it is understood that the water in which the wall of rock was to be built ranged in depth from 25 to 52 feet. To build up the wall would require 2,290,000 tons of rock. The government demanded that a

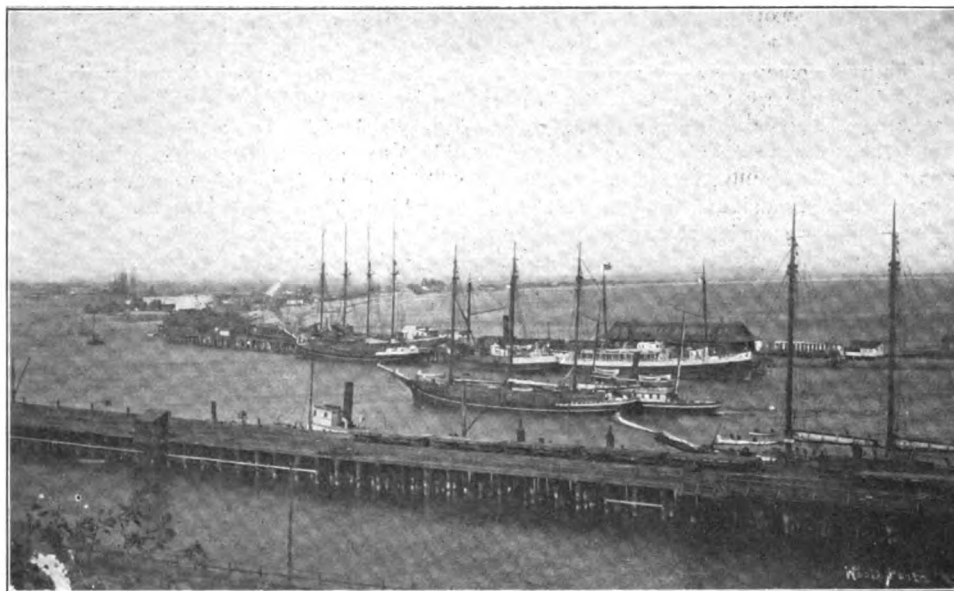


FIG. 1.—THE ENTRANCE AND INNER HARBOR AT SAN PEDRO.

Santa Barbara, due to the islands off shore, affords fair protection to shipping, but all these ports are not harbors, and the growing commerce of the past decade has been seriously hampered by the lack of a port where vessels could lie at all times; a port in the vicinity of Los Angeles—the center of commercial activity in Southern California.

This demand has found expression in various directions. An attempt was made to build a wharf at Redondo, a few miles from Los Angeles, and many vessels stop there, but they lie at the long wharf in the roll of the surf, and would be obliged to leave in a gale, which, it may be said, rarely comes. A similar port is seen at Santa Monica, where the Southern Pacific Railroad has built a fine wharf directly out to sea in an open roadstead; and piers have been constructed at Newport,

floor, or base, should first be made by the deposition of small stones on the ocean bottom, regularly arranged, which was to be the platform upon which the wall was to rest. Upon this, for a distance of 12 feet upward from the bottom, there should be a mass of stone which should weigh 130 pounds to the cubic foot; none of the pieces to weigh less than 100 pounds; one-third to weigh not less than 1,000 pounds, and one-third of the pieces not less than 4,000 pounds in weight. At this stage, or when a height of 12 feet is completed, the base must be 90 feet in width, and from this point on the wall to gradually lessen in width, being formed entirely of rocks ranging from 6,000 to 16,000 pounds in weight, the largest being piled upon the outside, where it is assumed the sea will break with the greatest force.

The work of construction is now being vigorously carried on by the contractors. San Pedro is a small town, reaching out in the direction of a prominent headland known as Point Firman. At a point about 2 miles from the town and opposite the location of the breakwater, the construction company have begun operations by building an elaborate bridge of piling, Fig. 2, which reaches out from shore like a huge snake. This is to enable the cars loaded with rock to reach the head

disappear, while a mass of foam and water rises high in air—a striking spectacle from the distant shore.

The work is progressing rapidly, and for some distance the breakwater is at the surface, so that the sea breaks upon it. A sea captain, who leaves the port of San Pedro daily, informed the writer that already the effects of the wall are appreciable, and that the heavy swell which formerly was met at the entrance of the outer harbor is no longer felt in so



FIG. 2.—CONSTRUCTION PIER USED IN BUILDING THE BREAKWATER.

of the breakwater. The rock comes from several quarries—Chatsworth and Declez being the most important, the latter 60 or 70 miles distant. The Chatsworth stone, judging from samples taken by the writer from the car while it was being weighed, is a very soft and friable sandstone, easily crumbled in the fingers; yet experts have pronounced it amply sufficient for the purpose. The inspector stated that only about one-fifth of the work was to be made of this stone. The rock from the Declez quarry, at Colton, is a granite abounding in mica,

marked a degree, and in his estimation in a year and a half the sea wall, while not completed, will be fully up to all that is required of it. It was estimated that five years will be required to complete the work, at which time the breakwater will rise 14 feet above water at low tide and about 7 at high tide. The contract price was \$2,375,000, and it is estimated that 92,000 carloads of stone will be required. The upper portion, or superstructure, will be more or less ornamental, and the entire work promises to be attractive as well as useful, and justified by the commercial growth of the wealthiest county in Southern California. It is interesting in this connection to glance at Dana's "Two Years Before the Mast," and read his description of this precise locality, where but a few decades ago he lay in a ship to receive the hides which were tossed over the cliff, the vessel lying off shore ready to run before the winter southeasters. At present all this is changed. The inner harbor is filled with ships and steamers, and in a short time the great breakwater will provide a harbor of refuge suitable for the largest navy in the heaviest gale.

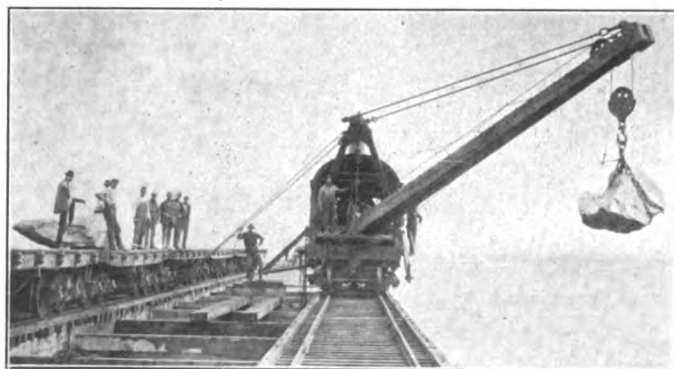


FIG. 3.—HANDLING THE STONE ON THE CONSTRUCTION PIER.

undoubtedly well adapted for the purpose. The cars are loaded at the quarry with huge blocks and shipped without delay to San Pedro; when within an eighth of a mile from the pier each car is rolled upon a scale and weighed, then when the entire trainload has been weighed the cars are sent down the line out upon the long pier. Here is stationed a powerful engine, with a crane, which lifts the stones, Fig. 3, from the cars and turns them over the water, where they hang suspended a moment until the engineer jerks a release string, shown in Fig. 3, and the huge rocks fall with a crash and

Argentine Battleships.

Specifications for the new battleships authorized to be constructed for the Argentine Republic are generally reported as follows:

Displacement, 19,000 tons; speed, 21 knots; armor, 12, 10.8 and 6 inches. The armament is to consist of ten 12-inch guns, mounted in five turrets; fourteen 6-inch rifles and eighteen 3 and 2¼-inch rapid-firing guns. The propelling machinery is to consist of turbine engines, and hydraulic gear is to be adopted for operating the turrets. There will be two sister ships, the *Moreno* and *Rivadavia*, which, added to the four of the *Belgrano* type already owned by the Republic, are considered to represent a full equivalent to the three Brazilian *Dreadnoughts*, *Minas Geraes*, *Sao Paulo* and *Rio de Janeiro*.

THE EFFECT OF BOSSING UPON RESISTANCE.*

BY PROFESSOR HERBERT C. SADLER, D.SC.

In the course of testing some models of twin-screw ships with different shaped sterns, the writer had occasion to try the effect upon the resistance of placing the bossing at different angles, and it was thought that the results might be of interest to the members of this institution.

Before proceeding to discuss the results obtained in these experiments, the writer would call attention to the important part that some of these appendages might play in connection with the resistance of a modern vessel. Most of the passenger vessels of to-day are fitted with bilge keels, and nearly all with two; if not, in the case of turbine-driven vessels, three or four lines of shafting. The stream line flow around a vessel is still somewhat of an unknown quantity, although

* Read before the Institution of Engineers and Shipbuilders, February, 1909.

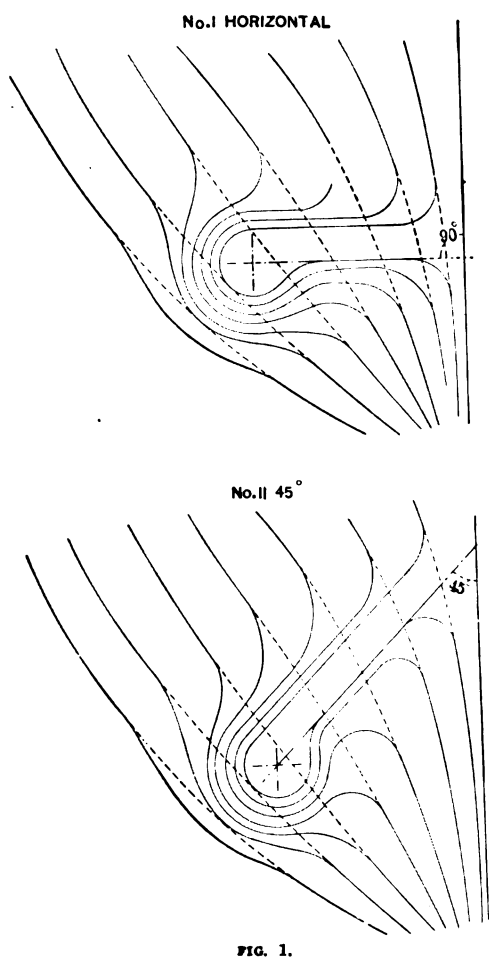


FIG. 1.

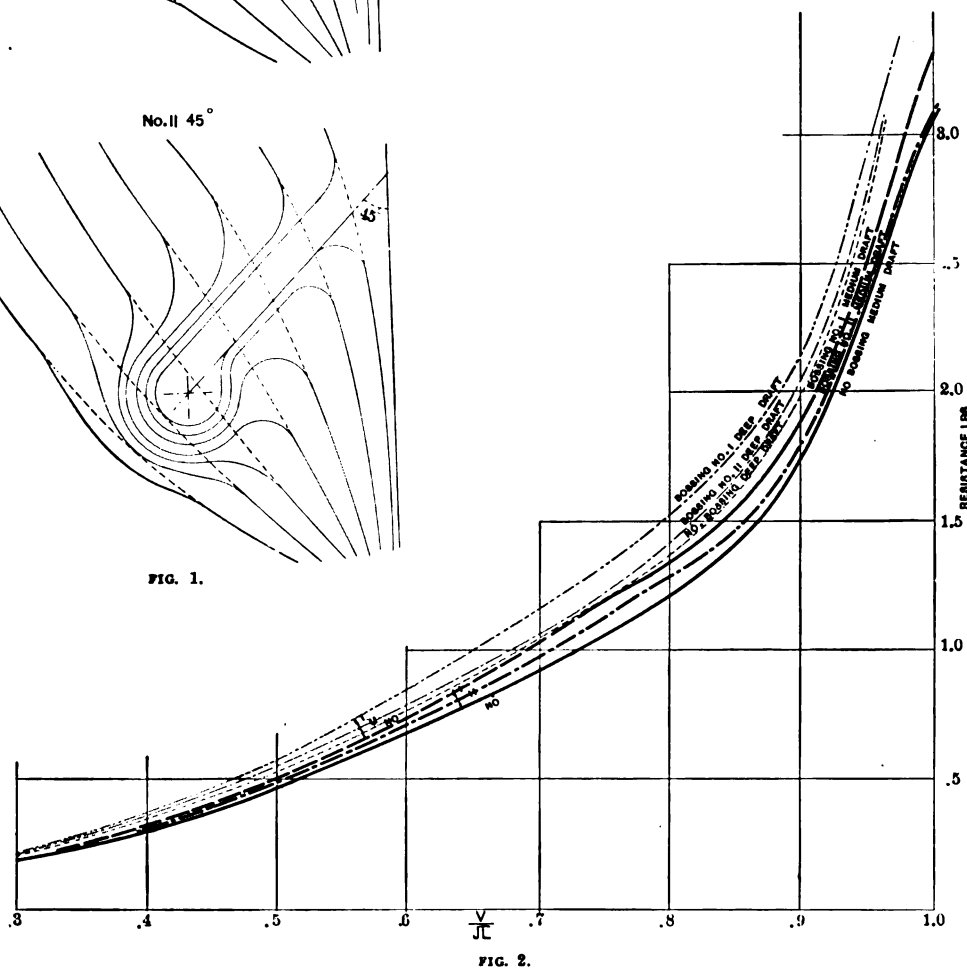


FIG. 2.

in a valuable paper by Naval Constructor D. W. Taylor, United States navy,† the probable path of the water has been indicated for a number of different types. A casual glance at these lines will show how easy it is to place an appendage in a most disadvantageous position, so far as resistance is concerned; in fact, the resistance might easily be increased 20 percent by improper design.

The following experiments, although applying directly only to the form tested, nevertheless indicate in a general way the course to be followed in placing the bossing for a twin-screw ship.

The following are the particulars of the model used: Length, 10 feet; breadth, 1 foot 3 inches; draft, 6 inches and 7 inches.

Draft.	Block Coeff.	Pris. Coeff.	Mid. Sect. Coeff.
6 inches.	.635	.663	.958
7 inches	.653	.677	.964

The model was first run "naked" at the above drafts, representing the medium and deep-load drafts in the actual vessel. The bossing was afterwards added to the same model. The two types of bossing tried are shown in Fig. 1, and represent practically the two extreme cases, viz.: one with the appendage horizontal and the other inclined at an angle of 45 degrees to the vertical. The form of the bossing is that in common use, the top being kept as straight as possible, while most of the curvature is on the underside; an arrangement which gives a more simple construction in connection with the plating than that where both the top and bottom have the same form.

The tests with the bossing were made at the same dis-

† Society of Naval Architects and Marine Engineers, New York, 1907.

placement as that corresponding to the 6-inch and 7-inch drafts of the naked hull. This method was adopted in preference to that of equal drafts, as giving a more direct comparison. The difference in draft, due to the displacement in the bossing, is not great, as the additional displacement is only .84 percent for No. I. and .88 percent for No. II. bossing. Fig. 1. The net addition to the wetted surface is about 3 percent for the horizontal type, and about $3\frac{1}{2}$ percent for the inclined type. The curves for total resistance are shown in Fig. 2, plotted to a speed-length ratio base, and give the results for both the medium and deep drafts.

Observation of these curves shows that at all practical speeds for this form the horizontal type of bossing is greatly inferior to the inclined type. Notwithstanding the fact that the latter gives an increased wetted surface between the limits of speed-length ratio of from .7 to .85, the increase in total resistance over that of the "naked" hull only varies from 3 to a little over 4 percent, while for the horizontal type the corresponding increase is from 10 to 11 percent.

The effect of the two systems is, however, better seen by referring to Fig. 3. In this case the residuary resistance is shown for the two displacements, the corrected surface friction in each case having been deducted.

Instead of actual residuary resistance, the resistance per ton of displacement is plotted, and instead of speed the abscissæ represent speed-length ratio, or speed in knots, divided by the square root of the length in feet. Mention is made of this method of plotting because the curves so obtained are independent of size or density of water, and will apply to any ship of which the model is a type. This has been adopted as the standard method of plotting residuary resistance, both at the University of Michigan and at the United

THE ROYAL MAIL STEAMSHIP "ARAGUAYA."

BY FRANK C. PERKINS.

The Royal Mail Steam Packet Company's steamship *Araguaya*, of 10,500 tons gross, was constructed at the Belfast shipyard of Workman, Clark & Company, Ltd., to Lloyd's highest requirements for first class passenger steamers. She is a steel twin-screw steamer, 515 feet long with 61 feet beam and a depth of 34 feet. The poop is 42 feet long, the bridge 274 feet and the forecastle 89 feet.

The propelling machinery consists of two quadruple ex-

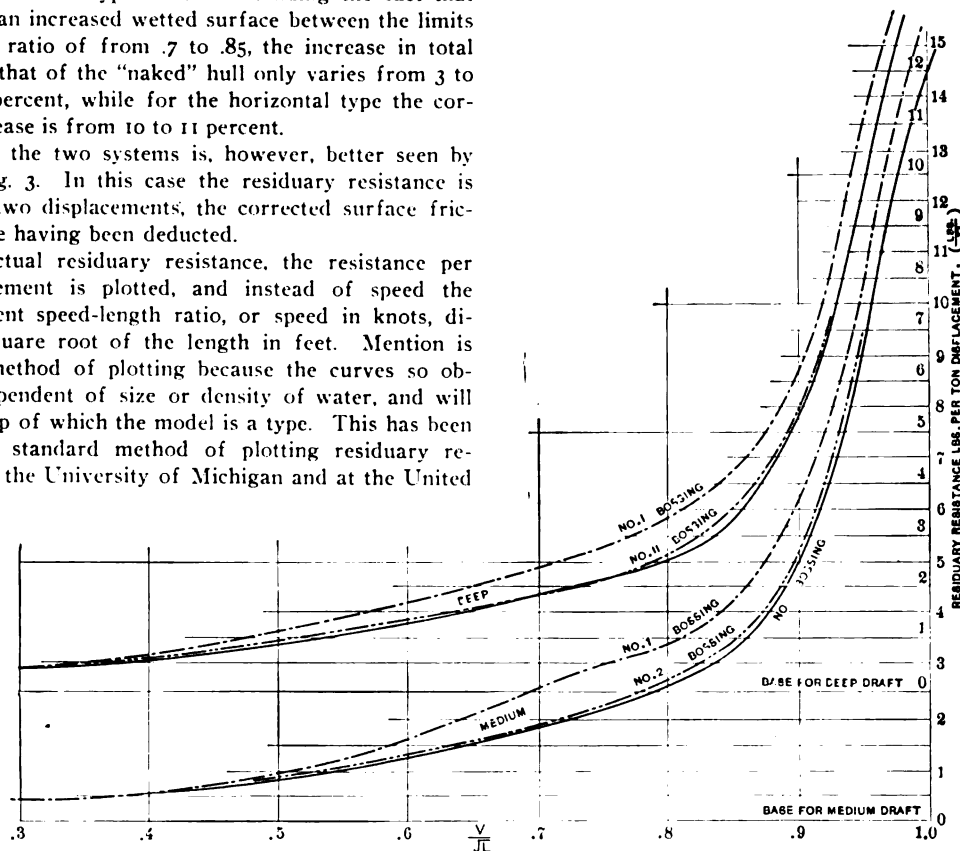


FIG. 3.

States government tank at Washington, and is the simplest form for direct application to practical problems.

Within the limits of speed-length ratios before mentioned, the inclined system of bossing for the two displacements increases the residuary resistance by a very small amount, which at some speeds is negligible, while in the horizontal type the increase averages from between 30 and 35 percent.

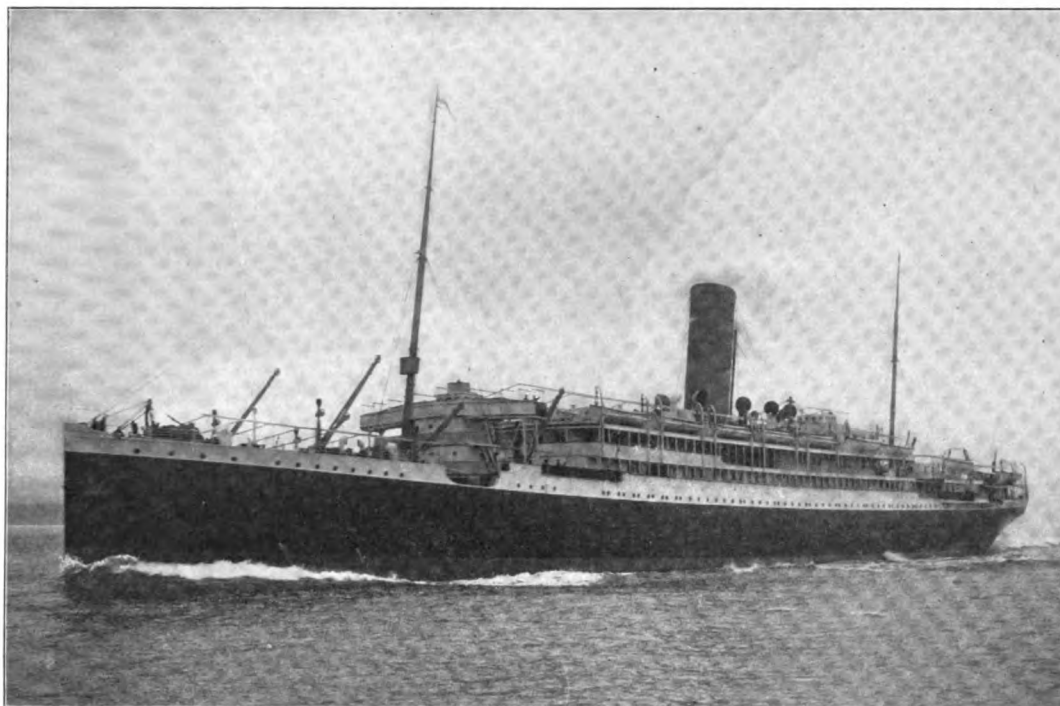
Comparing the curve of residuary resistance for No. II, or the inclined bossing with that of the "naked" hull, it is obvious that the stream line flow cannot have been materially changed in the two cases. This conclusion, to a certain extent, bears out Taylor's stream lines, and if the buttock lines of No. I. be compared with those of No. II., and also with the "naked" hull, the result is, perhaps, only what might have been expected.

The above experiments give, however, quantitative results for purposes of comparison, and emphasize the importance of attention to such details in design. Attention may also be called to the fact that a number of fast Atlantic liners have been fitted with horizontal bossing.

pansion engines, with a stroke of 40 inches, and cylinders measuring 27, 38, 54 and $70\frac{1}{2}$ inches in diameter. The main condensers are placed on the outside of the engines, and are attached to the back of the columns by brackets. The steam is condensed outside the tubes, the circulating water passing through them. There are large centrifugal pumps, capable of supplying the condensers with water to maintain the necessary vacuum even when the engines are running at full speed in the tropics with the sea water at 85 degrees F.

The crank, tunnel and propeller shafting is of steel, considerably increased in diameter beyond the Board of Trade requirements. The propellers are of bronze, each propeller having three adjustable blades, and constructed to turn outboard when driving the vessel ahead.

Steam is supplied by six boilers of the cylindrical multi-tubular type, all built of steel, and designed to carry a working pressure of 215 pounds per square inch, and so arranged as to be stoked from two holds. The boilers are fitted with forced draft on Howden's open-stokehold system, the air being supplied by two large fans, placed in recesses in the after stoke-

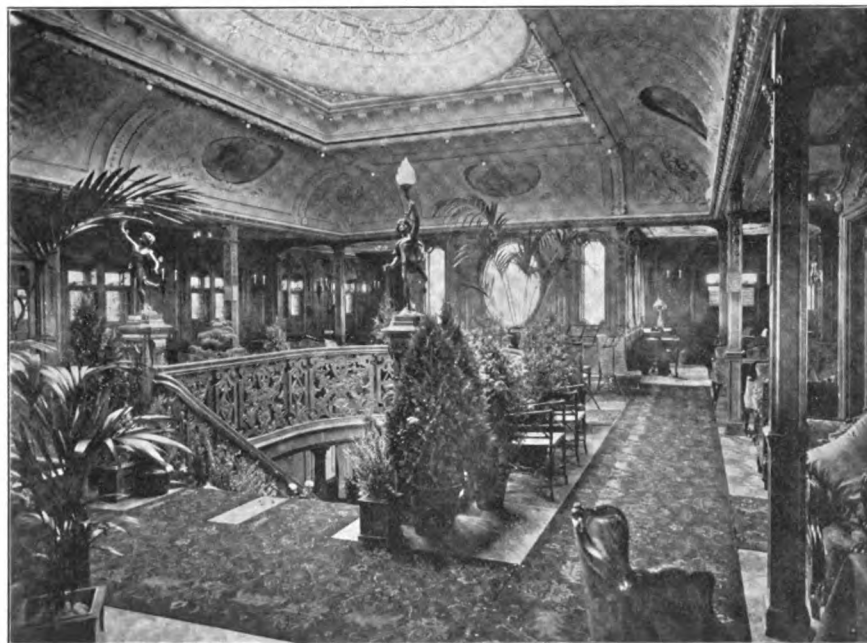


THE ROYAL MAIL STEAMSHIP ARAGUAYA.

hold. Each stokehold is also provided with See's ash ejectors, with subsidiary ash hoists in addition.

The *Araguaya* is constructed with a cellular double bottom, and, including the cargo holds, there are over thirty watertight compartments, so that with the invariable excellent discipline maintained by the Royal Steam Packet Company's commanders, she is as safe at sea as when in dock, and is practically unsinkable. Several of the main holds are insulated and fitted for the reception of meat cargoes, and the passengers' supplies are also stored in insulated chambers.

There has been provided complete ventilation by currents of pure air, forced throughout the ship by twenty-two large fans working at equal pressure, with a separate exhaust to eliminate the impurities. Other novel features include an electrically-operated fog syren, responding to the pressure of a button on the bridge; electric means for setting twenty-six clocks at each noon by instantaneous signal from the chart room, and hydraulic noiseless cranes to load and discharge cargo, saving the passengers from the irritating whirr of noisy steam winches.



MAIN SALOON OF THE ARAGUAYA.

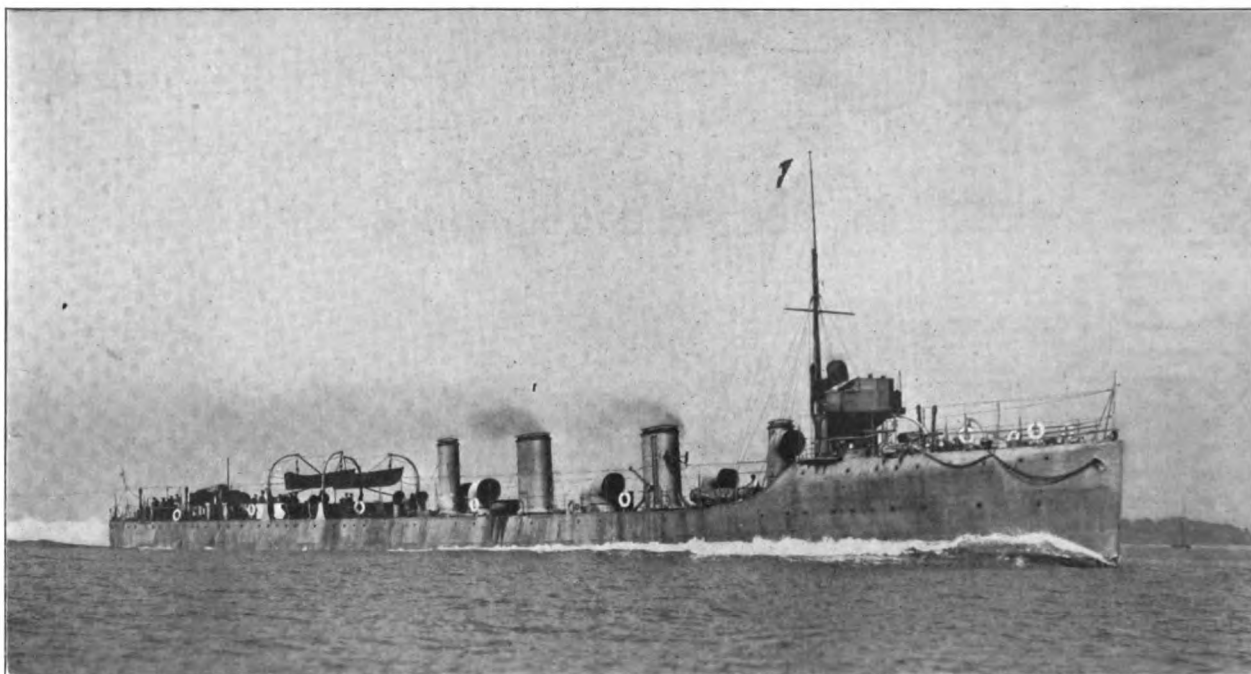
THE TORPEDO-BOAT DESTROYER "MOHAWK."

BY E. OMMELANGE.

The turbine-driven destroyer *Mohawk* is one of the most successful of the 33-knot ocean-going destroyers now in the service of the British navy. She is 270 feet long, with a beam of 25 feet. The propellers are supported on brackets, the central propeller, driven by the high-pressure turbine, being at a lower level, and 5 or 6 feet abaft the side propellers. The latter are attached to the shafts, on which are mounted a cruising and a low-pressure ahead turbine and an astern turbine.

The vessel is constructed with very fine lines forward, and, as in the "River" type, there is a high forecastle with a bridge, which commands a splendid view, not only of the horizon, but of the complete deck. Even at full speed and with the wind at full force, sending spray from the crest of every wave, no water found its way on to the forecastle from the beginning

section, like the staves in a section of a barrel, and the continuation of the line of curvature of each tube, passing through the top drum in line with the end manhole, allows each tube to be inserted or withdrawn through this manhole, so that it is possible to withdraw any tube without disturbing the remaining tubes, and as every tube has the same curvature they can be readily cleaned internally by a tube brush having a rigid handle curved to the same radius. Large down-take tubes are fitted. Ordinary manhole doors are arranged on all drums. As the inclination of the generating tubes is considerable, and usually varies between 40 and 60 degrees, the circulation is definite and rapid, keeping the tubes free from deposit. No special water baffles or separator plates are found necessary, the usual internal steam pipe being sufficient to give dry steam. Patent baffles are so fitted as to divide the uptake into two or more parts, in such a manner that the gases are drawn equally over the whole tube surface and at right angles to it,



THE MOHAWK AT FULL SPEED.

to the end of the trial trip, but the spindrift frequently washed over the waist of the ship. The hull is constructed entirely of high-tensile plates and angles, the tensile strength being from 37 to 40 tons per square inch; the rivets are of the same steel.

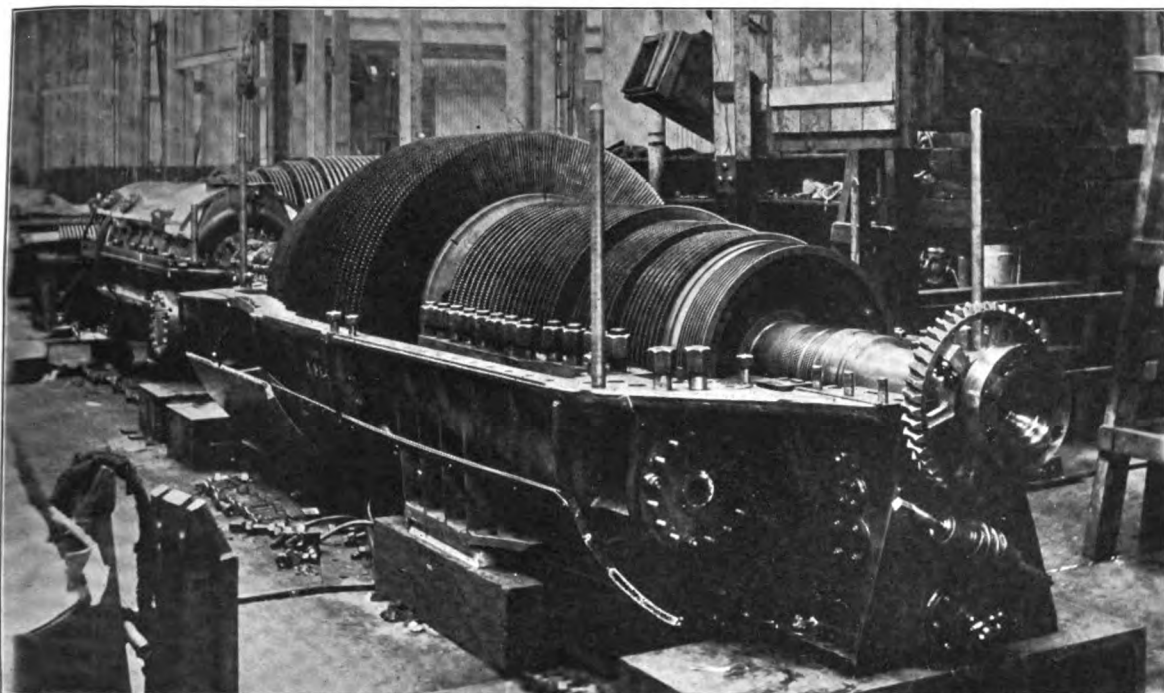
The armament of the ship includes three 12-pounder quick-firing guns, two of them mounted forward and one of them aft, with two revolving tubes on deck for firing 18-inch torpedoes.

The propelling machinery, which is the most important feature of the ship, consists of Parsons steam turbines, supplied with steam from White-Forster watertube boilers, burning oil fuel on the Admiralty system. There are three main boiler rooms, each containing two boilers, all arranged on the center line of the ship. The foremost boiler and that next to the engine room have independent uptakes, while the other four are in pairs, each pair being divided by a center line bulkhead, but connecting with one funnel. The radius of curvature of each tube between one of the lower water drums and the upper steam and water drum is the same, and the curvature is only sufficient to determine the direction of movement due to expansion, and also to facilitate cleaning and repairs. The tubes are arranged in position in a transverse

without offering any resistance or increasing the air pressure. Air holes are arranged at the sides and ends for the admission of air above the grates.

The boilers are worked on the closed-stokehold system, with forced draft, and on the trial the pressure averaged about 4 inches. In each stokehold there are a main-feed and auxiliary-feed pump, two fan-engines, and the pumps required in connection with the oil fuel. The oil-fuel tanks are at the ends of the ship.

The machinery includes seven turbines: a high-pressure cruising and intermediate cruising, a high-pressure main and two low-pressure main turbines—all for going ahead, with two astern turbines. One cruising, one low-pressure main ahead and one astern turbine are mounted on each wing shaft; the high-pressure main turbine alone is on the center shaft. It will be understood that at low power the sequence of steam is through the high-pressure cruising to the intermediate-pressure cruising, thence to the high-pressure main, and to the low-pressure main turbines. For intermediate speeds, the high-pressure cruising turbine is cut out, the steam from the boiler entering the intermediate-pressure cruising turbine, thence going to the high-pressure main turbine and to the low-pressure main turbines. For full speed both cruising



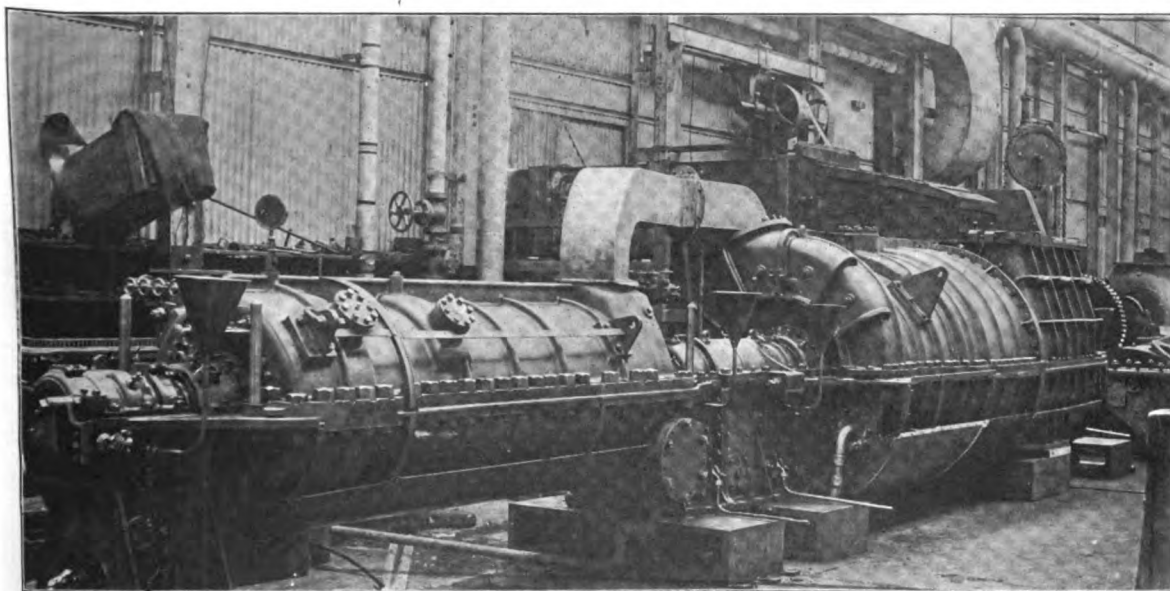
ONE CRUISING, ONE LOW-PRESSURE MAIN AHEAD AND ONE ASTERN TURBINE ARE MOUNTED ON EACH WING SHAFT.

turbines are out of action. This arrangement necessitates a considerable number of valves and a duplication of steam pipes. There are two main stop valves for the two main steam leads from the boiler room, with a cross connection between them. There are also connections from these to several other valves, mounted on the forward bulkhead in the engine room, so that the supply of steam can be passed direct from the boiler to any one of the seven turbines in the ship. The low-pressure ahead and astern turbines alone are used in maneuvering, the central shaft running idle. The starting platform is in the center of the engine room, between the low-pressure turbines, and all auxiliary engine stop valves for the various units in the engine room are workable from this position. In maneuvering the ship the two side wheels are used, and these, through shafts and bevel gears, communicate with a

vertical lever fulcrumed at one end, so that when the valve of the ahead low-pressure turbine is opened the valve of the astern turbine is closed.

The arrangement of the engine room is very convenient, the various pipe connections to the side turbines being immediately over the high-pressure turbine. The condensers are in the wings, the circulating pumps being located at the forward end, while the dry-air pumps and wet-air pumps are situated on each side of the wing shafts aft. At the after end of the engine room there is a distiller and an evaporator, and their respective auxiliaries are located close by.

The rotors for the turbines vary in diameter from $31\frac{1}{2}$ inches, in the case of the high-pressure cruising turbine, to $44\frac{1}{2}$ inches in the high-pressure main turbine, and 66 inches in the low-pressure turbine. The blades range in length



TURBINES FOR ONE OF THE WING SHAFTS UNDERGOING TESTS AT THE BUILDERS' SHOPS.

from $\frac{3}{4}$ inch to 11 inches; the latter in the low-pressure ahead turbine have been fitted separately on the original Parsons system. Cast steel has been used for the discs, while forged steel was, of course, adopted in the case of the spindles, which do not extend through the rotors. In the case of the high-pressure turbine the thrust bearing is at the forward end, and in the other shafts it is between the cruising and the low-pressure turbines. The astern turbine, as is usually the case, is incorporated in the low-pressure ahead turbine, and the exhaust bend is built up of steel plates. The steam pipes are of steel, with gunmetal expansion pieces.

The propeller shafts are of forged steel, being $7\frac{1}{2}$ inches in diameter, with a $3\frac{3}{4}$ -inch hole. The propellers are three in

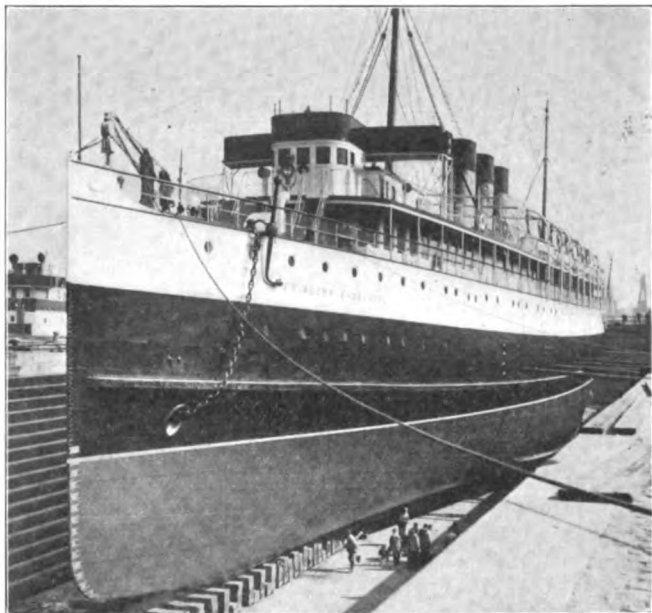
which points to the advantage of oil fuel for high-speed work. Another important advantage was the facility with which full speed was developed; for on her trial trip, seventeen minutes after weighing anchor, the vessel steamed at $34\frac{1}{2}$ knots over the measured mile.

THE PRINCESS CHARLOTTE.

The *Princess Charlotte*, recently built by the Fairfield Shipbuilding & Engineering Company, Ltd., Glasgow, for the Canadian Pacific Railway Company, is a steel twin-screw steamer of the following dimensions:

Length over all.....	342 feet.
Breadth, molded.....	42 feet 6 inches.
Depth to shelter deck.....	26 feet.
Draft	13 feet.
Displacement	2,850 tons.
Indicated horsepower.....	5,500
Speed	20 knots.
Tonnage, gross.....	3,600 tons.

The propelling machinery consists of two direct-acting, triple-expansion, surface-condensing engines, each having four inverted cylinders, with four cranks on the Yarrow-Schlick-Tweedy system of balancing. The low-pressure cylinder is at the forward end and next to it is the high pressure. Then comes the intermediate cylinder and the second low pressure is the aftermost. The cylinders are 24, 40, $43\frac{1}{2}$ and $43\frac{1}{2}$ inches in diameter, with a common stroke of 33 inches, and are designed to develop about 5,500 indicated horsepower when driving the ship at 20 knots speed. The valves of the

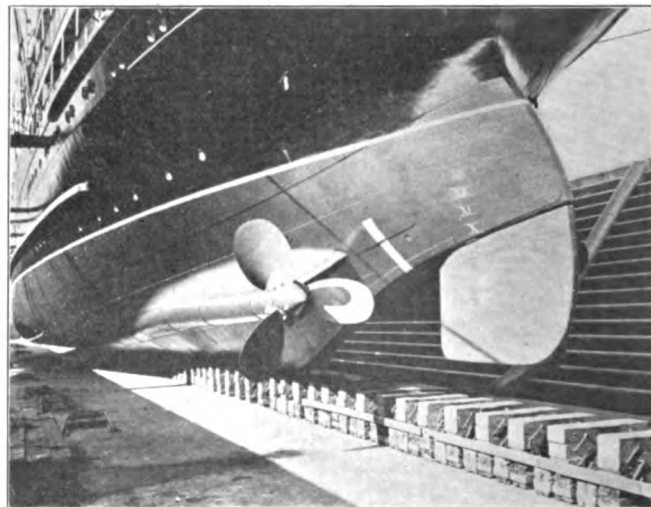


THE PRINCESS CHARLOTTE IN DRY-DOCK.

number, of Stone's manganese bronze, each with three blades.

The performance of the *Mohawk*, as regards speed, reliability, fuel economy and seaworthiness, was very satisfactory, and it is said that the vessel established a record in speed and in fuel consumption. The conditions of contract between the Admiralty and the constructors, Messrs. J. Samuel White & Company, of East Cowes, were that the vessel should maintain an average speed of 33 knots for six hours, a rate which was to be determined by the revolutions required per nautical mile from the mean results of six runs over the measured mile made at the middle of the trial. The vessel ran six times over the measured mile at the Maplin Sands, in the Thames Estuary, and her mean speed was then 34.511 knots, the mean revolutions being 757.3 per minute. On the six hours' run the average speed was, on the basis given, 34.245 knots. Further, the contract required that the oil-fuel consumption should not exceed 1 pound per square foot of heating surface, while the result obtained was only 0.86 pound, or 14 percent less than specified. The total consumption for the six hours' run was $68\frac{1}{4}$ tons, and as the vessel carries in all 148 tons of oil, she has a radius of action of 435 nautical miles at this high speed. At the ordinary cruising speed of 14 knots, however, she will be able to steam 1,500 nautical miles.

All further tests have proved that the *Mohawk* is well suited for active work. As far as the steam generating plant is concerned we may add that it may be noted that there was an entire absence of smoke, and the steadiness of the oil consumption and of the steam supply was most marked, all of



STERN OF THE PRINCESS CHARLOTTE, SHOWING THE ANGULAR BOSSING, PROPELLERS AND BALANCED RUDDER.

high-pressure and intermediate-cylinders are of the piston type, the others are flat, and all are operated by the Stephenson double-link motion.

There is one condenser for each engine, of steel plate with solid-drawn brass tubes. The cooling water for condensing the exhaust steam is circulated through the condensers by two centrifugal pumps, and the condensed steam is withdrawn from the condensers by Weir's patent air pumps. There are two Weir's standard main feed pumps, which draw from the surface feed heaters and discharge into the boilers. For distilling there is one evaporator, capable of producing 20 tons of fresh water per twenty-four hours.

The propellers have three blades each, of manganese bronze, and the bosses are of cast steel. The blades are accurately machined and balanced. There is no outboard shafting, the

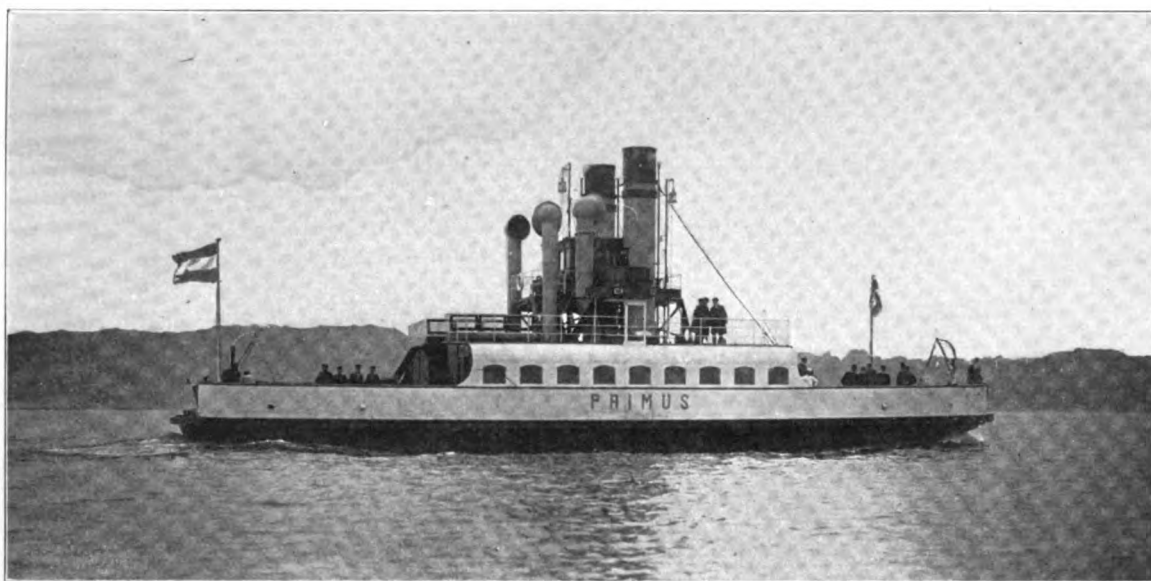
frames of the ship being bossed clear aft to the propeller brackets. The propeller brackets are of cast steel, and are fitted with zinc protectors to prevent corrosion.

The steam generating plant consists of six single-ended steel boilers of the ordinary multitubular type, each working at a pressure of 160 pounds per square inch. They are each 15 feet 6 inches in diameter and 11 feet long, and are arranged in two boiler rooms. All the furnaces are of the Morison suspension type, working under Howden's system of forced draft, air being supplied by three large fans, each driven by an independent inclosed steam engine. The total grate surface of all the boilers is 366 square feet, and the total heating surface 14,640 square feet, giving a ratio of 40 to 1. For the quick disposal of ashes, two See's ash ejectors are fitted, with which it is only necessary to shovel the ashes

provision is made for carrying cargo and cattle. The crew and firemen's quarters are on the orlop deck forward, and messing and sleeping accommodation is provided for a large number of waiters and cooks on the orlop deck aft.

The vessel is fitted with a balanced rudder of the builders' own special type, which is worked by a steam tiller controlled from the flying bridge. The anchors are worked by a powerful steam windlass, while a warping capstan aft enables the vessel to be easily handled in harbor.

The speed trials of the *Princess Charlotte* took place on the Firth of Clyde on the 14th of September. These consisted of a progressive trial of four double runs on the measured mile at Skelmorlie, and one six-hour run at full speed. During the six hours at full power, the mean speed obtained was $20\frac{1}{2}$ knots, half of a knot in excess of the guaranteed speed.



ONE OF THE NEW FERRY BOATS FOR KIEL HARBOR.

into a hopper on the stokehold floor, and without further manual labor they are carried through a tube to the ship's side and discharged overboard.

The ship is built to Lloyd's A 1 class for channel service, and has five decks, named in the following order: Orlop, main, shelter, promenade and shade deck. She is fitted with three funnels and two pole masts. Designed for the Canadian Pacific Railroad Company's mail and passenger service between the cities of Vancouver and Victoria, provision has been made to accommodate a large number of passengers. On the promenade deck there is a very broad deck house, occupying nearly the full breadth of the deck, and extending from the shelter bulkhead forward to within a few feet of the stern. Along the sides are staterooms for first class passengers, and the space between these cabins is fitted up as an extensive sitting room. There is a large coach roof on the deck above, which gives this sitting room a lofty and handsome appearance. On the promenade deck aft is the first class smoke room, and on the same deck forward is the observation room, which has large square windows. Above the promenade deck is the shade deck, with officers' rooms and pilot house and the flying bridge. The lifeboats are all stowed on the shade deck. Below the promenade deck is the shelter deck, and the accommodations here are somewhat similar to those on the promenade deck. There are staterooms along the sides, and both forward and aft between the staterooms there is a general saloon. Below the general saloon aft is the first class dining saloon on the main deck, with seating accommodations for 130 passengers. On the main deck forward

FERRY BOATS FOR KIEL HARBOR.

BY OUR BERLIN CORRESPONDENT.

Two ferryboats have recently been constructed by the Howaldtswerke to provide an adequate communication between the city of Kiel and the suburb of Gaarden, situated on the opposite bank of the Kiel Strait. These two boats are used for a service carried on at intervals of from four to six minutes; while a third one is provided as a reserve. Both ends of the boats are symmetrical, but the height of the free board at the ends, which is subject to a constant fluctuation, due to the landing of passengers and carriages, is controlled by bridges resting on flat pontoons with out-balanced valves, affording a slightly slanting landing bridge. The boats are provided at each end with a rudder and a screw propeller, and are designed on the type characteristic of ferry steamers. The principal dimensions are as follows:

Length over deck.....	98 feet 5 inches.
Length between perpendiculars.....	79 feet $\frac{3}{4}$ inch.
Breadth over deck.....	34 feet $\frac{5}{2}$ inches.
Breadth on waterline.....	36 feet $\frac{6}{4}$ inches.
Depth from upper edge of keel to the side of the deck.....	14 feet $\frac{5}{4}$ inches.
Draft, loaded (with double bottom and bunkers filled).....	11 feet 6 inches.
Displacement with above draft.....	442 tons.
Indicated horsepower.....	350
Speed	7.5 knots.

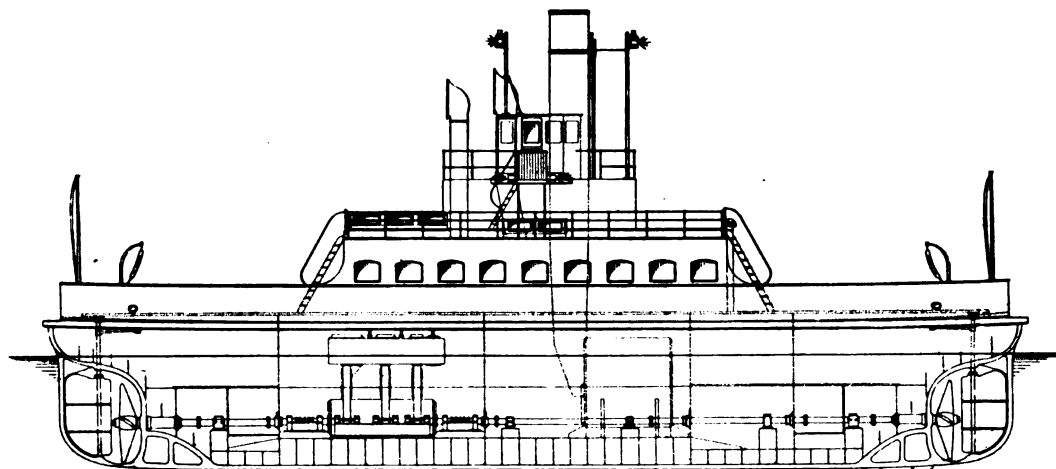
The safety of passengers is warranted by all the arrange-

ments usually adopted, in the case of up-to-date passenger steamers, as regards stability, number of watertight bulkheads, height of freeboard, etc. The comparatively large beam is a special feature, the width below the deck decreasing in a continual curve, which gradually passes below the water to the normal form of the frames. This design ensures a form of 'midship frames very favorable for the transverse stability of the boat, while giving the required draft and displacement.

The boats have been built of first-class Siemens-Martin steel, and are designed for conveying 600 passengers of 176

gines are installed on the platform; on the extensions of these shafts are mounted wheels for steam and hand operation. The steering apparatus is so designed that the rudder, when actually out of use, is automatically stopped from the pilot house, the position lamps being actuated at the same time. In order to protect the stopped rudder a substantial frame, built up by the stern post, is provided; this can also be used for ice-breaking.

Oak planking, $10\frac{1}{4}$ by $10\frac{1}{4}$ inches, lined on the outer edge with flat iron, $\frac{7}{16}$ inch thick, is fitted around the entire boat,



PARTIAL INBOARD PROFILE OF KIEL FERRY, SHOWING ARRANGEMENT OF MACHINERY.

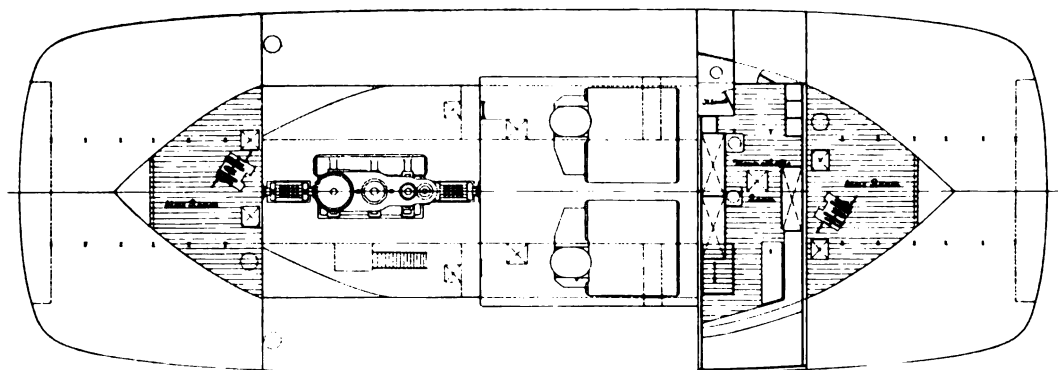
pounds each, or three teams of up to 12 tons each, located behind one another. They are divided into seven watertight compartments by four transverse and two longitudinal bulkheads, which are built watertight as far as the upper deck. The two longitudinal bulkheads limit the coal bunkers, which are situated at the sides of the engine and boiler rooms. The double bottom, consisting of eight watertight compartments, with a total capacity of 45 tons water ballast, extends throughout three-quarters of the length of the boats, and is intended both for storing the boiler feed water and ensuring the stability of the boats when empty. Each tank is provided with a suction pipe leading towards the main engine as well as with

and the hull is reinforced at its ends by special bulkheads within the range of this planking.

The propelling machinery comprises a triple-expansion engine, with surface condensers, designed for 350 indicated horsepower. The dimensions of the cylinders are:

High pressure.....	14 $\frac{3}{8}$ inches.
Medium pressure.....	22 $\frac{5}{8}$ inches.
Low pressure.....	36 $\frac{1}{2}$ inches.
Stroke	19 $\frac{11}{16}$ inches.

The three cylinders have been tested at water pressures of 265, 118 and 51 pounds, corresponding to their working pressures; they are covered with felt about 2 inches thick and ballast



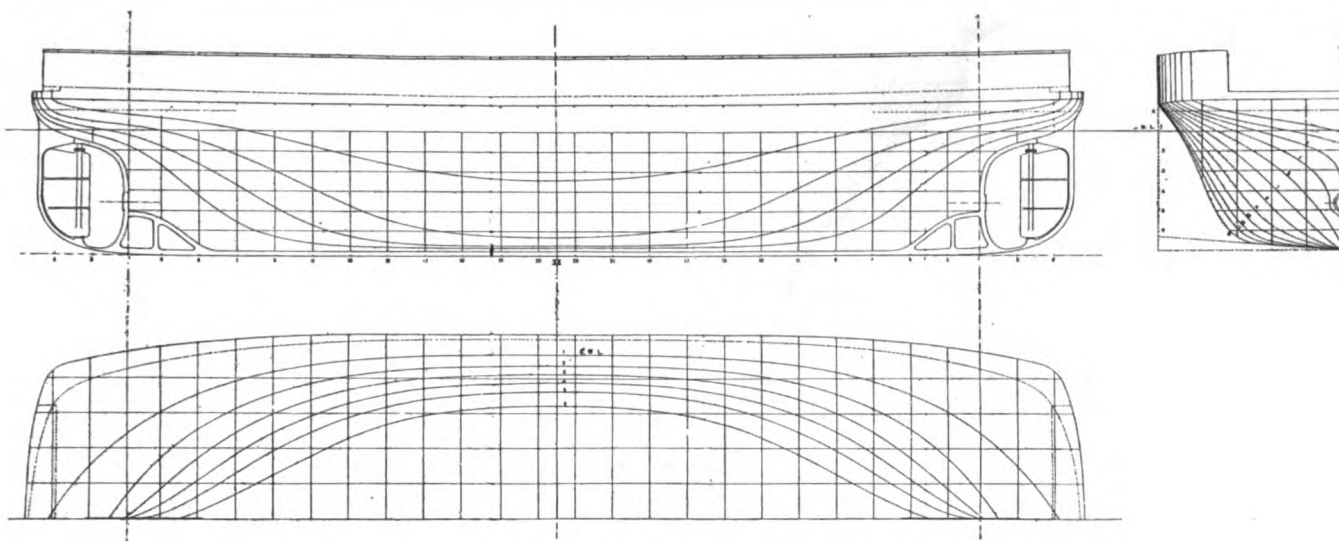
LOWER DECK PLAN OF KIEL FERRY.

air and level tubes. All the various parts of the double bottom are readily accessible through manholes.

A track, 6 feet $6\frac{3}{4}$ inches in clear width for the carriages to be transported, extends throughout the length of the boat, and is supported by special substantial channel beams supported by a double row of I-beam girders.

The ventilators to the engine and boiler rooms lead through the deck houses at the sides of the track; they are connected with two 21-inch fans for the engine room and two 25-inch fans for the stoke room. Two self-contained steering en-

steel sheets. An "Edward" pump, coupled to the main engine, draws the water from the condenser into the feed-water tank. In addition to a circulating pump, there has been provided an emptying and a feed pump, actuated from the cross-head of the engine. The propeller shaft, $7\frac{1}{2}$ inches in diameter, made of Siemens-Martin steel, extends throughout the length of the boat, and is supported on five bearings, the thickness of the thrust-bearing shaft being 25 percent above the limits prescribed by German Lloyd's. The piping throughout is of copper with soldered bronze flanges. All pipes which have to



LINES OF THE NEW KIEL FERRIES.

be protected against heat radiation are coated with insulating material. The exhaust from all the auxiliaries can be led either overboard or into the condenser.

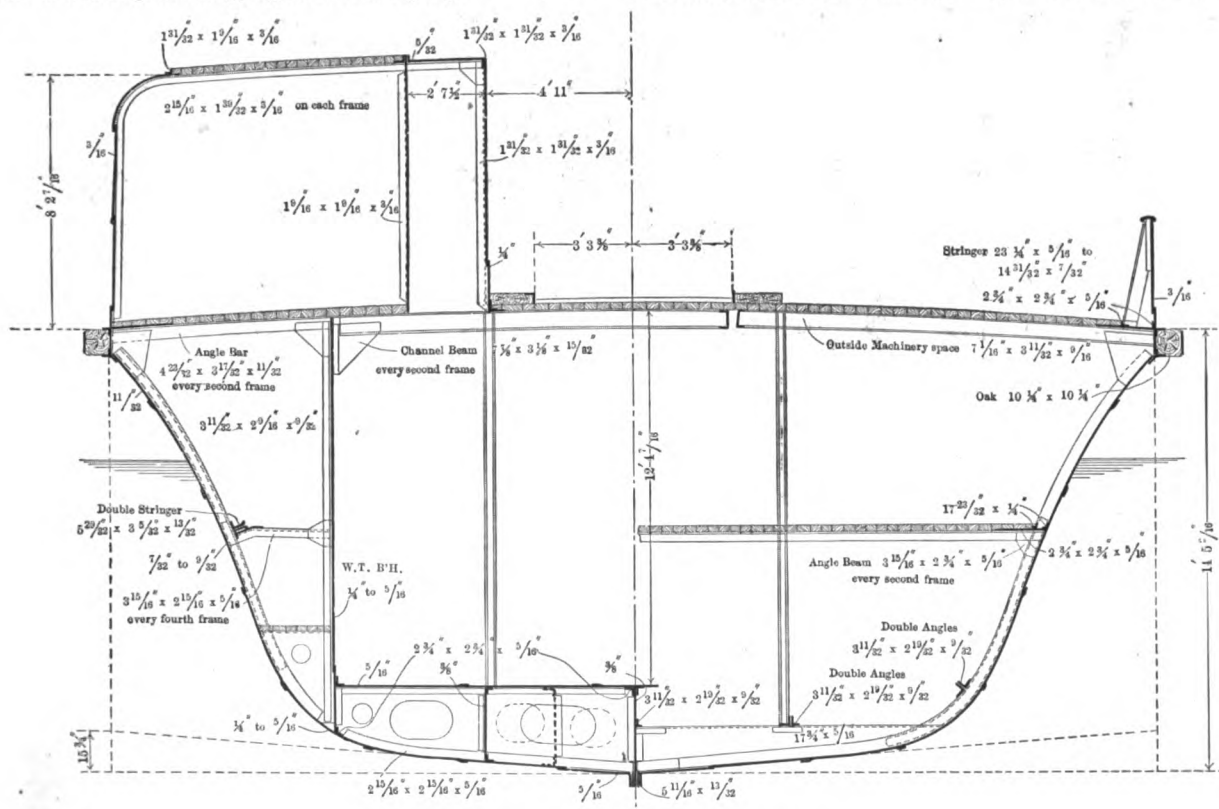
The dimensions of the two propellers (which are four-bladed cast steel) are as follows:

Diameter	8 feet 2½ inches.
Projected area	30.67 square feet.
Pitch	9 feet 3 inches.
Slip	.213

In designing the propellers it was necessary to make provision for starting and stopping the boats rapidly.

grate area of 40 to 1. The working steam pressure is 191 pounds per square inch, and the test pressure 265 pounds. The boilers are lined with asbestos felt and a sleeve of zinc-plated sheet iron. A "Worthington" pump, with a 4½-inch steam cylinder, a 2¾-inch water cylinder and a 3 15/16-inch stroke, is installed, which can be connected to the double bottom, the condenser, the air pump cistern or boilers, while being used as well for feeding the boilers and emptying and working in connection with washing the deck.

The electric current for lighting the boats is generated by a continuous-current shunt dynamo, at a tension of 100 volts,



MIDSHIP SECTION OF KIEL FERRY, SHOWING SCANTLINGS.

Steam is derived from two cylindrical return tube boilers, each 10 feet 7½ inches in diameter and 10 feet 5 inches long. Their total heating surface is 1,391 square feet, and their grate surface 35 square feet, making a ratio of heating surface to

operated by a compound engine with cylinders 5½ and 9 7/16 inches in diameter, operating at 350 revolutions per minute. Provision has been made in the engine room for installing a fire engine for harbor service.

During the trial runs, the first of these boats attained a speed of 8.16 knots with 104 revolutions per minute and 312.6 indicated horsepower, thus reaching at reduced power a speed nearly three-quarters of a knot above the normal figure. The coal consumption was found to be 1.54 pounds per indicated (metric) horsepower, as against the guaranteed figure of 1.65 pounds.

A SEA-GOING LIFE SAVER.

BY C. A. M'ALLISTER.

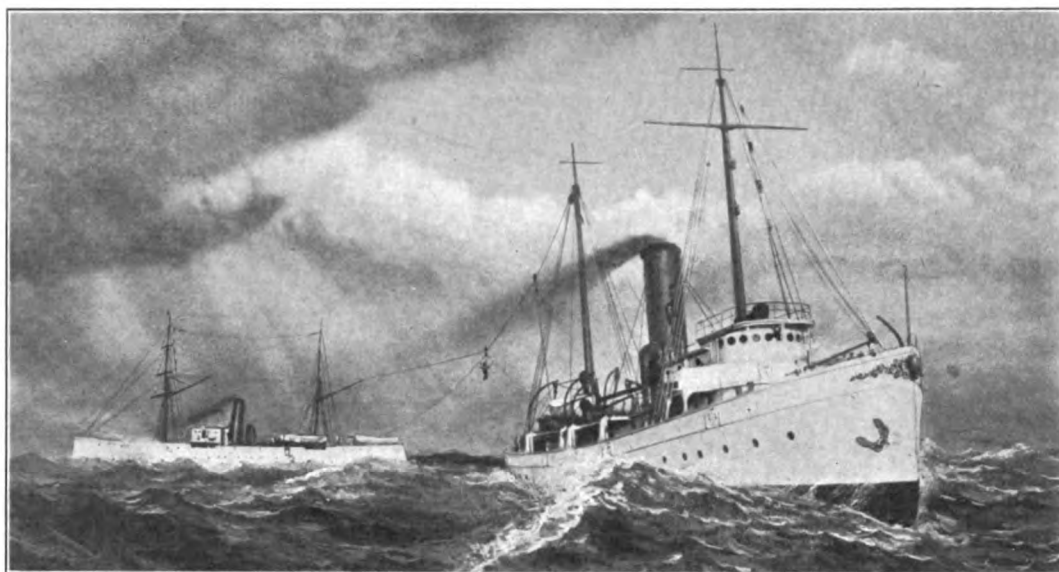
The new revenue cutter *Snohomish*, new en route to the Pacific Coast from Wilmington, Del., where she was constructed, is the first sea-going craft ever built exclusively for the purpose of saving life. In the building of this vessel the United States Government has furnished another example of its willingness and desire to aid humanitarian enterprises looking towards the welfare and safety of its people afloat as well as ashore.

The origin of this vessel may be traced directly to the loss of the steamship *Valencia* on Vancouver Island, B. C., which occurred on the night of Jan. 22, 1906, resulting in a loss of 136 lives. This disaster was the culmination of a number of

The vessel, it will therefore be seen, is of ample size and of proper design and power to fulfill her mission of saving lives at sea. For this purpose the following special equipment has been fitted:

1. Breeches buoy apparatus for removing shipwrecked persons from wrecks which are inaccessible to lifeboats.
2. Line-throwing guns to be used in connection with the above apparatus.
3. Two self-bailing and self-righting lifeboats.
4. Life raft.
5. Complete equipment of life buoys and life preservers.
6. Wireless telegraph.
7. Two powerful searchlights.
8. Telephotos or night-signaling apparatus.
9. Fire-extinguishing apparatus.
10. Wrecking pump and suction hose for pumping out vessels.

By far the most novel and interesting piece of the above special apparatus is the breeches buoy device for rescuing shipwrecked people when the conditions are such as to preclude their being taken off wrecks by the ordinary methods. This problem is so much akin to the coaling of ships at sea



THE SPENCER-MILLER LIFE-SAVING APPARATUS IN OPERATION.

shipwrecks in that vicinity, the seriousness of which can be judged from the statement that during the past fifty years nearly 700 persons have lost their lives in these waters. The public discussion and interest aroused by the loss of the ill-fated *Valencia* resulted in the appropriation by Congress of \$200,000 (£41,090) for the construction of "an ocean-going tug for the North Pacific Coast."

This has materialized in the *Snohomish*, a staunchly built and powerful sea-going tug, capable of withstanding any sea which may arise and any gale that may blow. The purpose of this sketch is more to describe some of the distinctive life-saving equipment of the craft than to expatiate on the details of her construction, yet it is well to state that she is a vessel of 795 tons displacement, having an over-all length of 152 feet, a beam of 29 feet, a depth of 17 feet 6 inches, and a normal draft of 12 feet 4½ inches. Her machinery consists of one Scotch boiler and one Babcock & Wilcox water-tube boiler, and a triple-expansion engine which developed, during a 4-hour test an average of 1,372 horsepower, with a resultant speed of 13.65 knots, a performance which can easily be bettered in case of emergency. Her propeller is 11 feet in diameter with a pitch of 11 feet.

by means of what may be termed a uniform tension cableway, that it was but natural to adopt the apparatus, the utility of which has been so successfully demonstrated in connection with coaling naval vessels at sea from colliers. This apparatus consists in general of a large drum on which the cable is coiled: this drum being operated by a double engine, the valve gear of which is so designed as to admit steam to the engines and take in the slack of the cableway when the vessels roll together and pay out cable when they roll away from each other; thus maintaining, at all times, a normal, uniform tension in the cableway between the two vessels. Consequently a contract was made with the one concern in this country which has made this difficult matter a success, the Lidgerwood Manufacturing Company, New York.

The modus operandi, as practiced during trials of the apparatus, and as will undoubtedly be adopted under actual service conditions, will be to anchor the vessel at a safe distance off shore from the wreck and shoot a small line over the ship in distress from the line-throwing gun. This line will be of sufficient strength to allow the crew on the wreck to haul aboard the block and whip. A tally board will be fastened to the block, upon which will be printed in several



ONE OF THE HALL LIFE-SAVING GUNS USED ON THE SNOHOMISH.

of the more important languages full directions as to how it is to be secured. Then the hawser or cableway will be sent on board by means of the whip, to which another tally board is tied, giving directions as to how it is to be secured. After the cableway has been fastened as directed, then by means of the whip, the breeches buoy, suspended from a traveler block, will be hauled off. The passengers and crew will then be taken off the wreck; one at a time if conditions permit, but if the vessel shows signs of breaking up, then two persons may be transferred at one trip. The life-saving guns used on the *Snohomish* are of the Hall improved type, built by the Lackawanna Marine Engine Works, Newburgh, N. Y. This gun is of the breech-loading type, mounted in such a way that the recoil from the discharge is taken up entirely by the mount itself, so that the gun can be accurately fired from any spot without being fastened securely to the vessel.

In the event that the sea will permit the transfer to be made by the use of boats, then the two-self-bailing and self-righting lifeboats will be lowered, and the rescue of those on the distressed vessel more rapidly effected. These lifeboats are of the most modern, self-bailing and self-righting metallic type, 24 feet long, and of the design which has proved most seaworthy and best adapted for general life-saving purposes under varying conditions of sea and location of wrecks.

In addition to these large lifeboats, a small, light *Otter* boat is provided. This is of the type used by the sealers and sea-otter hunters of the North Pacific and Behring Sea, and experience has demonstrated their great utility in rough water. They are light and buoyant as cork, and easily handled by two men. This boat could be used in running a light line to a distressed vessel, or even in the assistance of rescuing those on board. Circumstances might arise where a raft could be used to advantage, and for that purpose a metallic life-raft is at hand fully equipped for any emergency.

It is expected that much of the information as to disasters at sea or wrecks on shore will come to the *Snohomish* through the medium of the wireless telegraph, and as the set installed on the vessel is of the latest design, 1 kilowatt in capacity, with a sending range of 100 to 150 miles, and capable of receiving messages from a distance of 800 to 1,000 miles, the added facilities afforded by this equipment can be well appreciated.

The two large searchlights will be of great assistance during night work; and for communication with those on the

wreck, or in the life-boats away from the *Snohomish* at such times, the "Ardois" night-signaling set will be of especial advantage, as the ordinary code is well known to nearly all men who follow the sea in the position of a ship's officer.

It will be seen from the foregoing sketch that every endeavor has been made to provide the most seaworthy vessel possible of such a size as to be able to withstand all conditions of sea and storm, and yet capable of being readily handled when maneuvering about a wreck, fully equipped with all known apparatus and appliances for facilitating the rescue of those who may be shipwrecked and in distress along the dangerous shore of the North Pacific Coast.

THE WHIRLING OF SHAFTS.

It is quite possible for a shaft designed to transmit a given twisting moment to be entirely satisfactory when running at a comparatively low speed, and yet to suffer serious damage when it is run at a high speed, transmitting little or no twisting moment. Any slight initial bending of the shaft increases markedly as the speed increases until when a certain critical speed is reached the shaft breaks. This critical speed may be termed the "whirling" speed. In ordinary shop shafting whirling speeds are never or rarely reached. The introduction of the steam turbine has, however, been accompanied by such high shaft speeds that it becomes imperative to consider whirling in designing the shafting. Even if the shaft is perfectly true and balanced, an initial deflection, however slight, is quite sufficient to set up whirling, and if we run the shaft in the neighborhood of the whirling speed serious damage is invariably the consequence. It is the purpose of this article to give an account of the several formulæ from which whirling speed can be ascertained.

Consider a shaft with bearings at *A* and *B* (Fig. 1) rotating at an angular speed ω . Suppose the line *AB* denotes the initial



FIG. 1.

position of the shaft, and the curved line *APB* the disturbed position when running at speed ω . Let the co-ordinates of any point *P* in the shaft be *x*, *y*, referred to the end bearing *A* as origin. If σ denotes the weight per running foot of the

shaft, then the disturbing force on the shaft at *P* is $\frac{\sigma}{g} \omega^2 y$;

where *g* is the acceleration due to gravity. When equilibrium is reached the disturbing force is equal to the controlling force (the elastic force tending to restore the shaft to its original shape). The shaft is then under flexure, as though it were loaded with a load distributed as and equal in magnitude to the controlling force. If, therefore, *M* denotes the bending moment at the section of the shaft at *P*, we have (since the second differentiation of the bending moment curve gives the load curve) that

$$\frac{d^2 M}{dx^2} = \text{controlling force} = \frac{\sigma}{g} \omega^2 y.$$

Also in any loaded beam

$$M = EI \frac{d^2 y}{dx^2}$$

where *E* = coefficient of elasticity of the material and *I* =

moment of inertia of the section of the beam; whence it follows that

$$\frac{d^2 M}{dx^2} = E I \frac{d^4 y}{dx^4} = \frac{\sigma}{g} \omega^2 y.$$

or

$$\frac{d^4 y}{dx^4} = \frac{\sigma}{g E I} \omega^2 y = m^4 y; \text{ where } m = \sqrt[4]{\frac{\sigma \omega^2}{g E I}}$$

The solution of this differential equation is given by

$$y = A \cos h m x + B \sin h m x + C \cos m x + D \sin m x \quad (\alpha)$$

To obtain the constants A. B. C. D. we must apply the terminal conditions.

Case (1). Suppose the shaft be not contained at the bear-

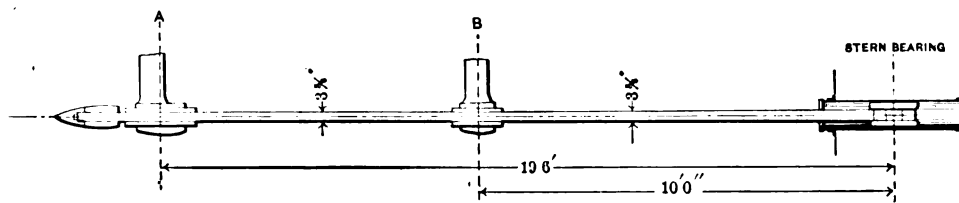


FIG. 2.

ings, that is, the bending moment at each end of the shaft at the bearings is zero. We have then that, when $x = 0$, $y = 0$ and

$$M = E I \frac{d^2 y}{dx^2} = 0,$$

and when $x = l$ (l being the length of the shaft between the bearings) then $y = 0$, and

$$M = E I \frac{d^2 y}{dx^2} = 0.$$

It then follows that

$$\frac{\sigma}{g} \times \frac{\omega^2}{E I} l^4 = \pi^4 \dots \dots \dots (\beta)$$

If N = revolutions of shaft per minute corresponding to whirling.

w = weight per cubic foot of the material (480 pounds for steel).

d_1 and d_2 = internal and external diameters in inches.

E = 29×10^6 pounds.

l = span in feet.

Then (β) reduces to

$$N = \frac{33,000 \sqrt{d_1^4 + d_2^4}}{P}$$

Case (2). Suppose the shaft be fixed in direction at one end, but free at the other. The constants A. B. C. D. in the equation (α) then vary, and the formula for the whirling speed then becomes

$$N = \frac{51,000 \sqrt{d_1^4 + d_2^4}}{P}$$

Case (3). If the shaft be fixed in direction at each end, e. g., a shaft in very long and very rigid bearings, we get

$$N = \frac{75,000 \sqrt{d_1^4 + d_2^4}}{P}$$

It is seen that the whirling speed of a shaft under different conditions of constraint at the bearings is represented by

$$N = \frac{K \sqrt{d_1^4 + d_2^4}}{P}$$

where K has a value ranging from 33,000 to 75,000.

If $d_1 = 0$ we get a solid shaft, and then

$$N = \frac{K d}{P}$$

where d = diameter of the solid shaft; that is, in the case of a solid shaft the whirling speed varies directly as the diameter and inversely as the square of the length of the shaft between the bearings.

Whirling cannot be prevented if we approach the whirling speed. We must so design our shafting, either by alteration

in the diameter or in the span that the maximum speed at which the shaft is to run, is well below the whirling speed.

It is seen that the assumptions on which our formulæ are based do not include the effect of several bearings in association with a continuous shaft, the effect of the thrust of the screw nor that of the overhanging propeller in propeller shafting. The general effect of these is to reduce the whirling speed.

As an example of the application of the formulæ let us consider the shafting shown in Fig. 2.

The designed revolutions were 1,300, the span from the middle of the stern tube to the center of the bearing at the shaft bracket at A was 19.6 feet, the diameter of the shaft (solid) was $3\frac{3}{8}$ inches. Using the formula

$$N = \frac{51,000 \sqrt{d_1^4 + d_2^4}}{P}$$

$$d_1 = 0, d_2 = 3\frac{3}{8} \text{ inches; } l = 19.6.$$

Hence, $N = 480$ revolutions per minute. This would never do, as we should have to pass through this speed to reach our speed of 1,300 revolutions per minute.

The obvious way out of the difficulty is to place another support between the stern tube and extreme bracket A. This can be done by placing the bracket B at 10 feet from the center of the stern tube, thus dividing the original span into two spans of 9.6 feet and 10 feet, respectively. Taking the larger span, 10 feet, as giving the worst case, we have the whirling speed corresponding to this span as given by the formula

$$N = \frac{51,000 \sqrt{d_1^4 + d_2^4}}{P}$$

where $d_1 = 0$, $d_2 = 3\frac{3}{8}$ and l now equals 10. The whirling speed is now

$$\frac{51,000 \times (3\frac{3}{8})}{100} = 1,850 \text{ revolutions per minute.}$$

This is well above our designed speed, so that the introduction of the additional shaft bracket B at about midway between the stern tube and the extreme bracket A keeps our designed speed well below the dangerous whirling speed.

G. R.

THE FRENCH ARMORED CRUISER ERNEST RENAN.

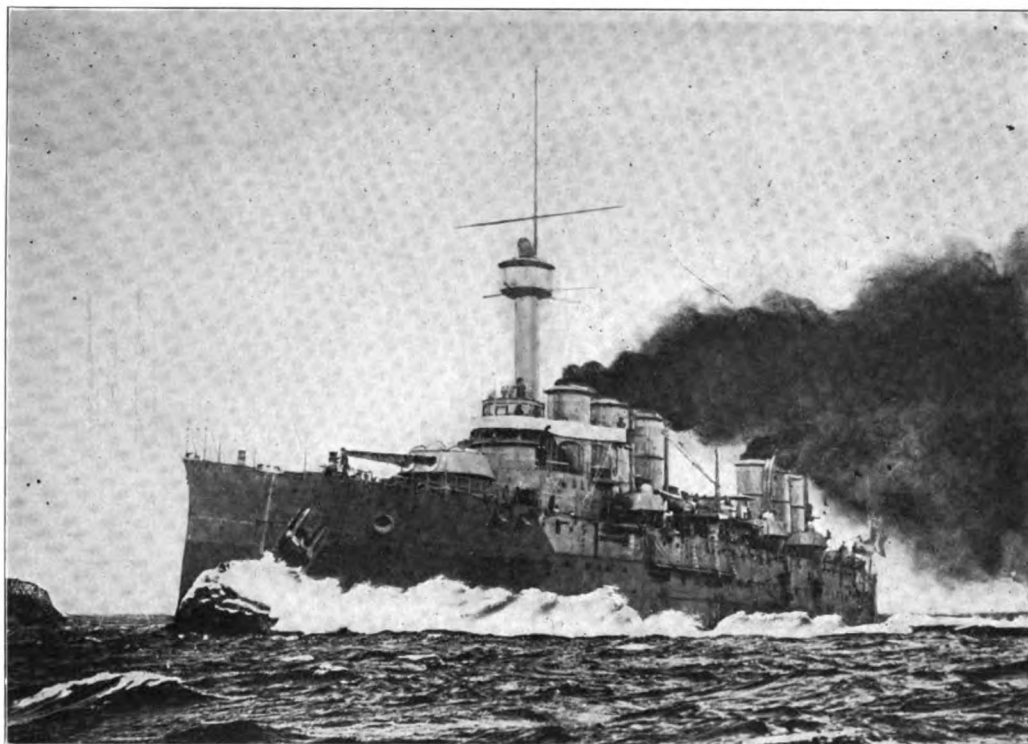
BY J. G. PELTIER.

Although authorized in the French naval programme of 1900 and contracted for in August, 1903, yet, due to the many changes in design made by the Admiralty, the *Ernest Renan*, the first of the 23-knot French cruisers, was not completed until April, 1908, and her official trials were not carried out until the latter part of the same year. The *Ernest Renan* is 515 feet 2 inches long on the waterline, with a beam of 70 feet 1 inch, and, at a draft of 26 feet 10 inches, displaces 13,644 tons. Three triple-expansion engines, aggregating 37,000 horsepower, were designed to drive the ship at a speed of 23 knots.

The hull is built of the highest quality mild steel, and there is no metal keel, simply a docking keel of teak and two

of which extend from the stem to within a few feet of the stern, terminating at an athwartship armored bulkhead. The belt extends 4 feet 7 inches below the normal waterline and 17 feet 1 inch above the waterline forward and 7 feet 7 inches above it aft. The first strake is 6.7 inches thick forward reduced to 4 inches aft. The second strake is 5 inches thick forward reduced to 3.6 inches aft, while the third strake extends from the stem 122 feet aft, or up to the casemates of the forward 6.5-inch guns; thus it will be seen that there is ample protection for the bow of the ship. The athwartship armored bulkheads extend from the outside plating of the casemates to the 7.6-inch turrets, and as an additional protection a cofferdam extends the entire length of the ship at the waterline.

With the exception of the spardeck, all decks are clear from all the ordinary auxiliary apparatus which was formerly found on all French warships. This is worthy of note, because



THE ERNEST RENAN AT FULL SPEED.

bilge keels, extending for about three-fourths of the ship's length amidships. The stem is of forged steel and the stern frame of cast steel. From the bottom of the ship to the lower protective deck the hull is divided into numerous main compartments, many of which are sub-divided into smaller watertight compartments. The double bottom extends to the protective deck. The shell plating is 11/16 inch maximum thickness below the waterline, and 13/32 inch above the waterline. The plates are worked according to the double-clincher, double-garboard and two-strake system.

As is the custom on all French warships the armor is arranged according to the "tranche cellulaire de protection" system, which consists of side armor and lower and upper protective decks. The highest point of the lower protective deck is a little above the load waterline. At the sides it is 4 feet 7 inches below this level. It is built of 1.4-inch mild steel plates, protected by 1.8-inch nickel steel armor on the flat and 2.6-inch nickel-steel armor on the slopes. The upper protective, or splinter, deck is at the height of the upper edge of the second strake of side armor. It is built of steel plates from 1.4 inches to 13/32 inch thick.

There are three strakes of side armor, the first and second

it shows the new policy inaugurated by the Admiralty. Between decks the vessel is roomy and well fitted out.

The armament consists of four 7.6-inch guns mounted in pairs in turrets, one forward and one aft of the superstructure, each having a total arc of fire of 228 degrees. There are twelve 6.4-inch guns, eight of which are mounted single in turrets on the spardeck, four on each side, the remaining 6.4-inch guns being located in four casemates, two forward and two aft. The secondary armament consists of sixteen 2.6-inch rapid-fire guns, of which twelve are located in the broadside battery and the remainder on the bridges. There are also four 3-pounder guns and two 18-inch submerged torpedo tubes. The fore-and-aft fire consists of two 7.6-inch guns and six 6.4-inch guns, while for the broadside fire four 7.6-inch and six 6.4-inch guns are available. The 7.6-inch turrets are protected by 8-inch armor and the barbettes with 5-inch armor, while the smaller turrets are protected by 5.5-inch armor. The casemates are protected by 5-inch armor.

The cruiser is propelled by three main engines of the four-cylinder triple-expansion type, located in three watertight compartments amidships. The cylinder diameters are: high pressure, 45 inches; intermediate, 68 inches; low pressure, 78

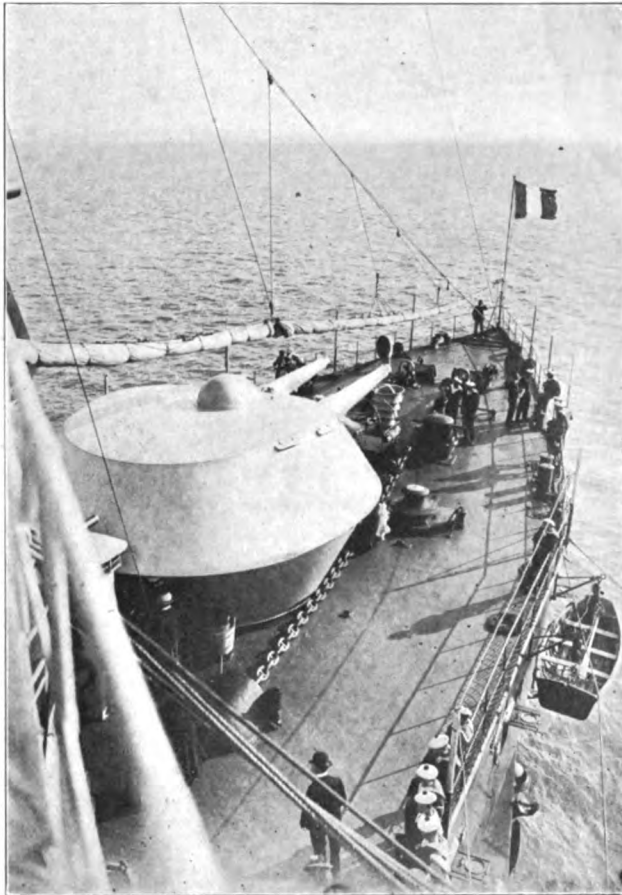
inches. The stroke is 42 inches and the revolutions per minute at full speed 133. The order of the cylinders from the forward to the after end is low pressure, high pressure, intermediate pressure and low pressure. There are three reversing engines, one of the usual type, another of a special type, and a third operated with oil. Each engine has two separate condensers with auxiliary apparatus in a special watertight compartment, while between the condensers are the thrust blocks.

Steam is furnished by forty-two Niclausse watertube boilers, located in watertight compartments containing bat-

forced draft blowers, are all electrically driven. There is a complete refrigerating plant for the magazines, which are close to the boiler or engine rooms. The distilling apparatus has a capacity for 35,000 gallons of fresh water per day.

If the *Ernest Renan* is compared with similar ships of the leading naval powers which were designed or laid down at the same time, it is easily seen that in the matter of armored protection she is superior to any other ships. As far as thickness of armor is concerned, assuming that the quality is the same on all the ships, the *Warrior* and *Minotaur* of the English navy have a slight superiority. The German type, although protected to an extreme height amidships, has no efficient protection fore and aft. The *Tennessee* of the United States navy has a better protected surface, but it is to be regretted that she has not been given better protection forward, as this will cause a certain inferiority in an engagement, because the bow is a vital part of a ship which is built for speed. It is distinctive of the French type that the bow of the ship is given ample protection far in advance of that provided in any other navy.

In the matter of armament this cruiser shows a great inferiority in caliber. It is certain that in an engagement at

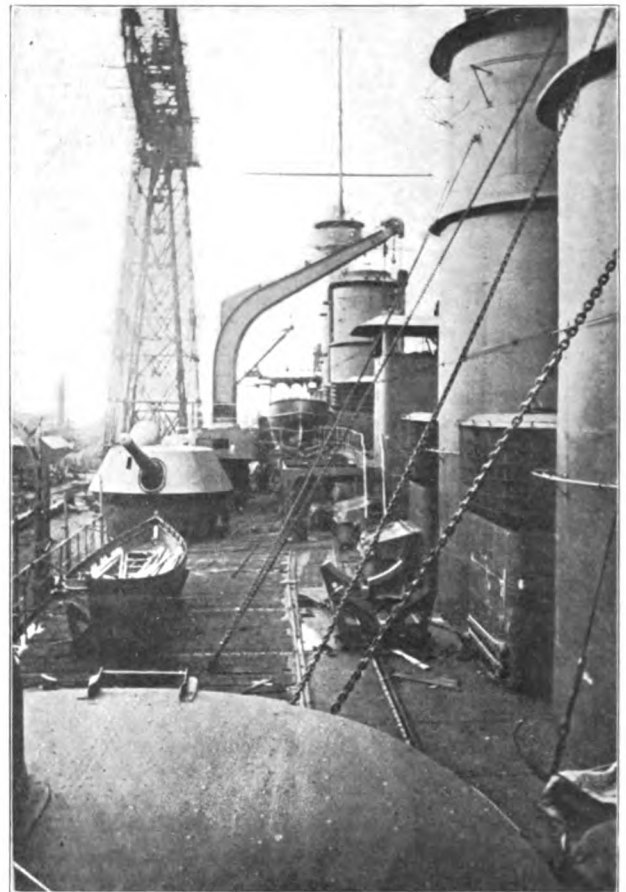


QUARTER DECK OF THE ERNEST RENAN.

teries of eight each. Part of the boilers are forward and part aft of the main engines. The products of combustion escape by means of six funnels, 91 feet high above the grate bars. The boilers are 7 feet 6 inches long, containing a total of 14,526 tubes, the upper ones being $2 \frac{15}{16}$ inches inside diameter and the lower ones $3 \frac{1}{16}$ inches inside diameter. The working steam pressure is 299 pounds per square inch, the total grate area 2,780 square feet, and the total heating surface 84,620 square feet. The boiler rooms are supplied with fresh air by electric fans and by steam-driven fans for forced draft. The ashes are removed by means of electric winches.

The total capacity of the coal bunkers is 2,300 tons, the normal supply being 1,524 tons, the steaming radii at 10 knots under these conditions being, respectively, 12,000 and 7,500 miles. At full speed the steaming radii are 1,650 and 1,028 miles, respectively.

The auxiliary machinery includes four dynamos, located in two separate watertight compartments on the lower protective deck. These dynamos operate at 110 volts, and have a capacity of 1,200 amperes each. All apparatus, except that requiring excessive power, is driven by electricity. The turrets, ammunition hoists, ventilating fans, with the exception of the



SPAR DECK OF THE ERNEST RENAN.

long range with any similar ships of other navies the French cruiser would be at a decided disadvantage. It seems to have been the rule in the French navy, at least up to the present time, that in a ship of certain tonnage the better part of the displacement is utilized for speed, the second consideration being armored protection, while the armament of the ship is the last consideration. French warships have been consistently developed to fight among themselves, but not to fight with similar ships of other navies. The caliber of the small guns is the smallest used in any navy in the world.

On her full-speed trials the *Ernest Renan* exceeded her

designed speed by nearly a knot and a half. Further details of the trials are shown in the table, which show that the engineering work, as carried out by the builders of the vessel, the *Chantiers de l'Atlantique*, has been most successful.

TRIALS OF THE FRENCH ARMORED CRUISER ERNEST RENAN.

6 HOUR TRIAL AT REDUCED SPEED, SEPT. 4, 1908.

	Number of Boilers.	Grate Surface Sq. Ft.	I.H.P.	Pounds Coal per I.H.P. per Hour.	Pounds Coal per Sq. Ft. Grate Area.	Speed, Knots.
Official Trial.....	6	417	3,336	1.45 1.32 to 1.54	11.61	8.59
Contract Figures.....	Not Specified.		3,250			Not Specified.

24-HOUR RUN AT NORMAL SPEED, AUG. 21-22, 1908.

Official Trial.....	42	2,680	22,560	1.53 1.43 to 1.65	12.86	21.23
Contract Figures.....	42	2,680	21,600			Not Specified.

10-HOUR FULL POWER RUN, SEPT. 8, 1908.

Builder's Trial.....	42	2,680	37,772	Not Determined.	24.58 to 25.65	24.44
Contract Figures.....	42	2,680	36,000	Not Specified.		23.00

THE TOTAL HEAT OF SATURATED STEAM.*

BY DR. HARVEY N. DAVIS.

For many years Regnault's classic formula, now sixty-one years old, which gives as the total heat of saturated steam

$$H = 1091.7 + 0.305 (t - 32) \text{ B. T. U.},$$

has been exclusively used by engineers in America, yet the remark is becoming common that such and such a method cannot be used because of the well-known errors in the steam table. It is therefore fortunate that, at least in the range from 32 to 212 degrees, physicists have recently provided a considerable number of good observations of the total heat of saturated steam apparently not noticed by the makers of our steam tables. It is equally unfortunate that, in all these years, there seems to have been not a single new observation above the boiling point. It is the purpose of this paper to show that certain observations recently made for very different purposes can be combined to give a better set of values of H above 212 degrees than do Regnault's direct measurements, and to propose a new formula for the range from 212 to 400 degrees, the accuracy of which is believed to be something like 0.1 percent. If these results are correct, Regnault's formula is too high by more than 18 B. T. U., or 1.7 percent at 32 degrees; too low by 6 B. T. U., or 0.5 percent at 275 degrees, and too high again above 380 degrees, the error increasing rapidly at high temperatures.

Some years ago attempts were made to determine the variation of the specific heat of superheated steam with pressure and temperature by means of throttling or wire-drawing experiments. These attempts failed because, as the observers themselves pointed out, the necessary computations were extremely sensitive to small errors in the assumed values of the total heat of saturated steam. Under unfavorable circumstances, an error of 0.1 percent in one of the values in the steam tables might make a difference of from 3 to 5 percent in C_p . It is then evident that, knowing C_p independently, one could reverse the process by which they tried to get it, and compute all the total heats in terms of any one by a method as insensitive to errors in assumed data as the other was sensitive.

* Abstracted from a paper presented at the December, 1908, meeting of the American Society of Mechanical Engineers, New York.

Fortunately, since these experiments, C_p has been determined independently and directly by Knoblauch and Jakob, of Munich, and by Thomas, of Cornell, and the accuracy attained by them is sufficient to make worth while such a recomputation of the wire-drawing experiments. In this work, Knoblauch's values of C_p will be used rather than Thomas'.

The throttling experiments used are those of Grindley, in England, in 1900; of Griessmann, in Germany, in 1904, and of Peake, in England, in 1905. The recomputation of these throttling experiments, considered in connection with Knoblauch's determination of the specific heat of superheated steam, lead to a new formula for the total heat of saturated steam, namely:

$$H = H_{212} + 0.3745 (t - 212) - 0.000550 (t - 212)^2.$$

The best available value of H_{212} seems to be 1150.3 mean B. T. U., which is the average of the values of Henning and of Joly. The total heat equation becomes

$$H = 1150.3 + 0.3745 (t - 212) - 0.000550 (t - 212)^2.$$

The range of this formula is from 212 to about 400 degrees F. The greatest error in Regnault's formula in this range is 6 B. T. U., at 275 degrees F.; but if Regnault's formula is extrapolated to higher temperatures, the error in it increases very rapidly. Below 212 degrees there is an abundance of modern data to show that Regnault's formula runs high, the error reaching 18 B. T. U. at 32 degrees.

Recomputed values of the specific volume of saturated steam differ from the standard values by 101 cubic feet, or 3 percent at 32 degrees, and by about 1 percent in the opposite direction at 275 degrees. Computed values of C_p at saturation agree strikingly with Knoblauch's values, and give additional confirmation to a conclusion already reached that of the three available sets of C_p values, Knoblauch's, Thomas' and Heck's, Knoblauch's is most deserving of confidence.

A steam table based on these new values will presently be published under the joint authorship of Prof. Lionel S. Marks and the present writer.

A NEW ORIENT LINER.

The Fairfield Shipbuilding & Engineering Company, Ltd., recently launched the twin-screw steamer *Oltway* for the Australian mail and passenger service of the Orient Steam Navigation Company, Ltd. The *Oltway* is a vessel of about 12,000 tons gross, with the following dimensions: Length, 552 feet; breadth, 63 feet 3 inches; depth, 46 feet. She is divided into ten watertight compartments, and has seven decks, viz.: boat, promenade, shelter, upper, main, lower and orlop. Accommodations are provided for 280 first class passengers, 115 second class, and 700 third class and emigrants. The vessel is schooner-rigged with two pole masts; has a straight stem and elliptical stern; is fitted with a balanced rudder and an auxiliary rudder for Suez Canal requirements.

At the forward end of the boat deck a large deck house has been built to accommodate the navigating officers, with the chart house and navigating bridge above. On the same deck amidships is the wireless telegraph station, the remainder of the deck being given up entirely as a promenade for first class passengers and the housing of the boats.

At the forward end of the promenade deck is situated the lounge and first class entrance, which has been tastefully decorated in Italian walnut. An elevator is provided to carry passengers from this entrance to the various decks and saloons. Adjoining this room is the first class music room and library, also finished in Italian walnut; the bay windows in this room are a special feature, enabling the passengers to have a full view of the promenade. Amidships, on the promenade deck, is a large deck house, which encloses the first

class staterooms. At the after end of this house is the first class smoking room, which is finished in Austrian wainscot with furniture to match. Opening from the smoke room at the after end is a veranda, which can be used as a deck lounge in fair weather. Around the deck houses is a broad and spacious promenade, under cover of the boat deck, and between the deck houses a large area of the deck has been kept clear for sports. Aft of and isolated from the first class is a covered promenade for third class.

The shelter deck forward of the bridge bulkhead is reserved for working the vessel and handling the cargo, and is fitted with powerful windlasses, capstans, winches and cranes. Aft of this bulkhead for a distance of about 60 feet the ship's side plating extends to the promenade deck, and continues aft into a deck house 160 feet long with a promenade on either side. At the forward end cabins-de-luxe or en suite rooms have been arranged. Immediately aft of these cabins, and in the center, is a large well over the first class dining saloon with special cabins on each side. The remainder of this house is fitted up with two-berth staterooms.

Continuing aft is the promenade for second class passengers, on which is situated the second class smoke room and music room and stairway leading down to second class accommodations below. At the after end, and divided from the second class by a barrier, is a comfortable music room and smoke room for the third class, with access to their living quarters.

The forward end of the upper deck is reserved for the wash-places and mess rooms for steerage, firemen and seamen. Aft of this, and extending to the grand staircase, are first class staterooms.

The first class dining saloon adjoins the main staircase, and is a magnificent hall extending in breadth from side to side of the ship, and measures over 50 feet in length. The saloon is finished in Italian walnut, and small tables are used. Overhead in the center of the saloon is an immense rectangular well, tastefully decorated, forming a gallery on the deck above. In the center of the ship, immediately aft of the first class dining saloon and forward of the second class dining saloon, are the galleys, pantries, sculleries, larder, bakery and confectionery. The second class dining saloon is 52 feet long by 63 feet wide, capable of seating 151 persons at one time. Aft of this are the second class staterooms, fitted up on the Bibby system, giving light to the inside rooms. At the after end of the upper deck are the third class accommodations.

The fore end of the main deck is reserved for the berths of the seamen and firemen. Around the main staircase are arranged staterooms on the Bibby system for first and second class passengers, with a children's saloon having seating accommodations for twenty.

The vessel will be propelled by twin screws, each driven by an independent set of quadruple expansion engines, balanced on the Yarrow, Schlick & Tweedy system. The high-pressure and the first intermediate-pressure cylinders have piston valves and the larger cylinders have ordinary flat slide valves, all worked by Stephenson's link motion, and controlled by steam reversing gear of the direct-acting type. The shafting is of hydraulic forged Siemens-Martin mild steel, each crank shaft being in four sections. The propellers have three bronze blades, fixed to cast-steel bosses.

A very complete installation of auxiliary machinery in duplicate will be fitted, comprising a complete electric plant, the latest improved steam steering gear, including Brown Bros. (Edinburgh) patent hydraulic telemotor, ventilating fans, telegraph, telephone, etc.

Steam will be supplied by four double-ended and two single-ended Scotch boilers, designed for a working pressure of 215 pounds per square inch. Howden's system of forced draft is fitted to all the boilers, the necessary air pressure being sustained by five large motor-driven fans.

A separate compartment forward of the boiler rooms con-

tains the refrigerating installation, consisting of three different machines, the two larger machines on the dry-air principle, for dealing with the cargo holds; and the third machine, on the carbonic anhydride system, for cooling the stores required for ship's use.

THRUST AND JOURNAL BEARINGS.

A perfectly lubricated journal bearing will maintain its lubrication and carry a load up to 500 pounds per square inch with a comparatively low friction loss. On the other hand, a thrust bearing will not support continuously more than 60 or 70 pounds per square inch, and has a very high friction loss. The reason for this difference is that the form of the bearing in the one case is well adapted to maintain lubrication, while in the other it is not.

Since the amount of work lost in friction depends upon the nature of the two surfaces in contact, it, of course, is evident that a bearing which, from its construction, tends to maintain a film of lubricating oil between the two metallic surfaces will be more efficient than one in which there is no such tendency, and, consequently, a metal-to-metal contact. In a journal bearing the oil is carried by the rotation of the shaft from the point of no pressure in the bearing, and is formed into a wedge, continually forcing apart the shaft and the bearing. In a thrust bearing of the usual type, consisting of one or more collars on the shaft bearing against corresponding collars on the thrust block, there is no point of zero pressure between the two surfaces, since they are pressed together with equal force at all points. Therefore, there is little opportunity for the oil to work between the surfaces, and consequently the bearing is incapable of supporting heavy-unit loads without developing an excessive amount of heat due to friction.

The fact that the ordinary thrust bearing is so inefficient as compared with a journal bearing has led to the introduction of a number of different means for reducing this friction. Special kinds of anti-friction metal have been brought out, also special kinds of engine oil for lubricating the bearing. Others have attempted to solve the problem by using ball or roller bearings, while still others have attempted to so construct the bearing surfaces of the thrust collars that a point of no pressure is obtained, and thus the bearing is lubricated similarly to a journal bearing.

In a paper read before a recent meeting of the Institute of Marine Engineers, Mr. G. B. Woodruff showed a diagram in which the coefficients of friction for both thrust and journal bearings are plotted as curves for varying speeds for different types of bearings. Friction being of two kinds, static and kinetic, it is evident that certain types of bearings may have a low starting friction, which will increase rapidly with the speed, or they may have a high starting friction, which will not increase very materially with an increase of speed. Of course it will depend altogether for what purpose the bearing is to be used whether it is advisable to have the friction a minimum at starting or at high speed. Both thrust and journal bearings have practically the same coefficient of starting friction unless ball or roller bearings are used. In that case there is a very low starting friction, although this advantage is lost when the speed of the shaft is increased.

A theoretically perfect journal bearing shows a sudden drop in the friction when the speed approaches about 10 feet per minute. On the other hand, the coefficient of friction of a flat thrust bearing falls slightly as the speed increases, although there is no sudden drop and the friction remains high. There is, therefore, some change which takes place in a properly lubricated journal bearing which does not take place in an ordinary thrust bearing. This change is the formation of the oil wedge forcing the two surfaces apart, which, as has already been pointed out, does not occur in a thrust bearing.

The chief advantage of a ball bearing is the very low

starting friction which it has compared with an oil-lubricated journal bearing. For heavy loads and high speeds, however, the advantage is not so great.

Roller bearings are now made to carry loads varying from a few ounces running at 30,000 revolutions per minute to loads of 250,000 pounds at 500 revolutions per minute and 1,500,000 pounds at 100 revolutions per minute. While such bearings have not been widely used for the thrust and journal bearings on propeller shafts for any except small boats, yet attention is now being turned to development in this direction. There are, however, an almost innumerable number of places on the various machines and tools used in shipyards where they can be used to great advantage. The largest anti-friction thrust bearing which has come to our notice was built by the Standard Roller Bearing Company, of Philadelphia. It is over 4 feet in diameter, weighs nearly 4 tons and carries a load of 1,500,000 pounds, or 750 tons, at 100 revolutions per minute.

For the purpose of ascertaining the relative starting and running friction of roller bearings as compared with ordinary bearings, Prof. Goodman, of the Yorkshire College, Leeds, made an exhaustive series of experiments with them, and gave the following facts as the results of his investigations. The friction per ton of load decreased as the load increased. Under a pressure of 100 pounds at 40 revolutions the bearing friction was at the rate of 8.512 pounds per ton of load, but under a pressure of 10,000 pounds at the same speed the friction had decreased to 3.584 pounds per ton of load. Speed had very little effect upon the coefficient of friction. In the case of a load of 1,000 pounds the coefficient was constant between the speeds of 40 and 480 revolutions per minute, but in the case of a load of 10,000 pounds it varied from .0016 at 40 revolutions to .0013 at 160 revolutions, and remained constant at this figure to 480 revolutions, the highest speed obtainable in the trials. The slight friction to be overcome in starting was practically the same as the running friction, while the end thrust was practically eliminated.

Ball bearings were not accepted at first without prejudice, because the balls were frequently found to break. Exhaustive investigations have, however, shown the proper proportions to be used in designing such bearings, so that now the same reliability can be claimed for these as for any other type of bearing. Manufacturers usually claim a saving of from 30 to 40 percent in power and oil by their use. The balls are now manufactured with marvelous accuracy, some being guaranteed correct to 1,000 of a millimeter and absolutely round.

The Thames Conservancy Motor Launch "Thames."

For some time past the Thames Conservators have found the small motor launch of considerable assistance to them in their duties, and the experience gained with the boat *Thames*, delivered by Messrs. Thornycroft in the late summer, has demonstrated the advantages to be derived from the use of larger craft of this description. The *Thames* is 45 feet long by 8 feet beam and 2 feet 7 inches draft. She is carvel-built of mahogany, with frames of American elm, decks of Kauri



THE THAMES.

pine, stem and sternpost of English oak and keel of American elm. All of the scantlings are of sufficient strength for sea or river use, as the launch is intended for patrolling the Thames from Oxford down to the mouth of the river. A cabin is fitted aft which contains a toilet, a pantry with shelves and sink, and a saloon with table, lockers, etc. The boat is provided with a folding canvas hood forward and a canvas awning over the after well, the motor being protected by a mahogany casing with hinged panels.

The motor has six cylinders, each with a diameter of $4\frac{1}{2}$ inches and a stroke of 5 inches, developing 45 brake-horsepower at about 1,000 revolutions per minute. The cylinders are of close-grained cast iron and water-jacketed, the circulating water being provided by a pump of the rotary gear type. Lubrication is forced by means of a pump. A reversing gear is fitted of the Thornycroft type in conjunction with a solid propeller. On her trials the launch attained a speed of 12 miles per hour.

The Motor Launch "Butterfly."

The *Butterfly*, which is a launch of a very staunch and serviceable type, is intended for cruising in the Bay of Smyrna. She is carvel-built of teak, with American elm timbers, 35 feet long by 7 feet beam, and with a draft of 2 feet 3 inches. There is a roomy cabin forward with hinged



THE BUTTERFLY.

porthole lights. The decorations are in white and gold, with upholstery of scarlet. The seats are provided with swing edges, to give increased width for use as sleeping berths. A 7-foot collapsible canvas boat is carried as a dinghy.

The boat is fitted with lifting slings, spray hood, awning, with deep sides as protection against the sun, and a hinged mast for emergency purposes, which carries a balance lug sail.

The machinery consists of a Thornycroft M4 engine and reversing gear. This engine has four cylinders, each $4\frac{1}{2}$ inches by 5 inches, and easily develops 30 brake-horsepower on the Russian or Roumanian kerosene, which is the only fuel obtainable in Smyrna. The "M4" is one of Messrs. Thornycroft's latest productions, and is specially designed for arduous marine work, having specially large bearings, crankshaft and camshaft, with a very substantially designed crankcase. The consumption of fuel is about .9 pint per brake-horsepower per hour. The cylinders are of strong design, with ample jackets, having large doors for cleaning. The ignition is by a high-tension magneto, which gives good results with kerosene fuel. The water circulation is maintained by a gear pump. Forced lubrication is fitted with a simple relief valve, by means of which the oil pressure can be regulated as desired and as required by the condition of the bearings.

The guaranteed speed of the boat on Russian kerosene was 11 miles an hour, and about $11\frac{1}{4}$ miles was easily attained on the trial spins.



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For the Advancement of Naval Architecture.

Two bequests have recently been made which will undoubtedly do much to advance the science of naval architecture. In response to the appeal of Professor Watkinson, who occupies the chair of engineering at Liverpool University, for the foundation of a chair of naval architecture in that city, Mr. Alexander Elder, the well-known shipbuilder, offers to provide a capital fund of \$60,831 (£12,500) for this purpose. Also, by the will of the late Dr. Francis Elgar a sum of \$7,786 (£1,600) is left to the Institution of Naval Architects for the endowment of a scholarship to be awarded as the Council may decide. After making other bequests, one-half of the residue of the Elgar estate, which will apparently amount to between \$156,000 (£32,000) and \$166,000 (£34,000), is eventually to be divided equally between the Institution of Naval Architects for the encouragement of the science and art of naval architecture and the University of Glasgow, to be held in trust for the furtherance of the objects of the John Elgar chair of naval architecture in that university.

It is to be hoped that before long means will be found for providing every technical school or college in which there is a department of naval architecture with a well-equipped experimental tank for towing models. This

need is very urgent both in the United States and Great Britain. In the United States there is at present, with the exception of the Government tank at Washington, only one other model towing basin in operation in the country; while in England, with the exception of the Admiralty tank, there are only two others, and as these are owned by private shipbuilding firms there is little chance to use them for research work. A well-equipped experimental towing tank is, of course, a costly piece of apparatus, and one which is expensive to operate and maintain. On the other hand, there is no more valuable means of investigating the various problems which must be solved by a naval architect than by such a tank, and under the direction of such men as are at the head of our schools of naval architecture such an establishment would have an incalculable value. Shipbuilders and others interested in the advancement of the science of naval architecture would do well to give the needs of technical schools and colleges more thought.

An Innovation.

The American Society of Naval Architects and Marine Engineers has decided to hold in future a semi-annual meeting sometime during the spring or summer months at some Western city. This year the meeting will be held at Detroit, Mich., probably the last week in June. Only three or four papers will be read each day, the remainder of the time being devoted to inspecting shipyards and various other industrial works. Any increase in the activities of this society, which in the past has done so much to advance the science of naval architecture, is, of course, to be gladly welcomed; yet the attendance and amount of interest shown at the annual meetings of the society in New York seem to us hardly sufficient to warrant this new departure. The fact that the meetings are to be held in some Western city may serve to stimulate the interest of lake shipbuilders in the activities of the society, and, if so, the attempt will have been worth while.

Large Ships and Ocean Travel.

Due very largely to the industrial panic, passenger traffic between the United States and Europe last year showed a decrease of 940,000 passengers and a decrease of about \$29,199,000 (£6,000,000) in revenue. This decrease in travel, coming at a time when a few of the largest and fastest ships crossing the ocean were at the height of their popularity, caused at least one conservative line in the North Atlantic trade to suspend dividends for the year. The tendency to travel in the largest, fastest and most luxurious vessels has been steadily growing of late, so that vessels of this type are the first to earn dividends in a dull year. Bookings for travel during the coming season have been fairly good, especially for mid-summer travel, and with the return of normal business conditions undoubtedly the smaller and slower boats will again be largely favored, because under these condi-

tions a greater number of people of moderate wealth will be traveling.

The world-wide depression in shipbuilding following two years of unusual activity and overproduction will probably call a halt on the building of extremely large vessels for a short time. Except for the new White Star liners *Olympic* and *Titanic*, no unusually large vessels are now projected. Since the launch of the White Star liner *Celtic* in 1901, marking the advent of ships of over 20,000 tons gross, fourteen ships exceeding this tonnage have been laid down. During the four years, 1892 to 1895, an average of eight vessels of 6,000 tons and upwards were launched per annum in the United Kingdom. In the following four years, 1896 to 1899, the average rose to twenty-five, and to thirty-nine for the four years 1900 to 1903. It dropped to twenty-seven for the four years 1904 to 1907, and during 1908 twenty-eight such vessels were launched. Of vessels of 10,000 tons and upwards only three were launched in the four years 1892 to 1895; seventeen were launched during the four years 1896 to 1899, while thirty-two were launched during the four years 1900 to 1903, and twenty during the four years 1904 to 1907. During 1908 ten vessels of 10,000 tons and above were launched. Of these, only one, the *Rotterdam*, was over 20,000 tons. In the United States the largest sea-going merchant steamer launched during 1908 was the *Oklahoma*, of 5,853 tons, and she was the only one of over 5,000 tons launched on the coast during the year.

The Outlook in Shipbuilding.

According to Lloyd's Register, the total output of the shipyards of the world during 1908 (exclusive of warships) was 1,833,286 tons (1,706,179 steam, 127,107 sail). According to the latest returns received by Lloyd's, the tonnage of all nationalities totally lost, broken up, etc., during the twelve months amounts to about 794,000 tons (557,000 steam, 237,000 sail). The net increase of the world's mercantile tonnage at the end of 1908 is thus about 1,039,000 tons. Sailing tonnage has been reduced by 110,000 tons, while steam tonnage has increased by 1,149,000 tons.

Of the tonnage launched during 1908, the United Kingdom has acquired over 30.25 percent. Of the total merchant tonnage output of the world during 1908, 50.75 percent was launched in the United Kingdom; but, if only seagoing steel steamers of 3,000 tons gross and upwards be taken into account (thus excluding vessels trading on the North American Lakes), out of the total of 179 such steamers of 1,050,741 tons launched in the world, over 63.33 percent of the tonnage has been launched in the United Kingdom. The output of mercantile tonnage in the United Kingdom during 1908 shows a decrease of 678,221 tons on that of last year, and is the lowest total recorded for fifteen years. The Glasgow district occupied the first place among the principal shipbuilding centres of the coun-

try, showing an output of 233,830 tons. Then follow in order Newcastle (174,259 tons), Belfast (153,517 tons), Greenock (103,470 tons), Sunderland (86,547 tons), Middlesbro' (57,210 tons), and Hartlepool (37,843 tons). In warship tonnage Newcastle leads with 21,830 tons, followed by Devonport and Portsmouth with 19,250 tons each.

In the United States the output was 287,603 tons, showing a loss of 42 percent as compared with 502,508 tons for 1907. The returns from Germany show a decrease of over 67,000 tons as compared with 1907. During the years 1900-1904 the average yearly output was about 204,000 tons. In 1905, 255,000 tons were launched, and in 1906, 318,000 tons. Since then there has been a considerable decrease, the present figures (207,800) being 110,000 tons less than two years ago. The tonnage launched in France, which had shown the striking decrease of 157,000 tons from 1902 to 1906, has since steadily increased. The figures for 1907 were 26,000 tons better than those for 1906, and the present total (83,400 tons) is 22,000 tons larger than that of 1907. The returns from Denmark, Holland, Italy, Japan and Norway show decreases of 33, 15, 40, 10 and 8 percent, respectively, while in Austria-Hungary there was an increase of about 170 percent over 1907. The totals for all other countries indicate a decrease of about 13 percent.

Having passed through a year of such universal depression, it is natural for shipbuilders to look forward to better conditions during the present year. The labor troubles, which assumed such formidable proportions in English yards during 1908, have been satisfactorily settled; but the amount of orders for new tonnage so far booked is discouraging, neither does there seem to be much prospect of an immediate increase of business. The past few years have witnessed the production of a large number of big ships, and it is unlikely that activity in this direction will be resumed for some time. A healthy improvement in the carrying trade of the world, however, must necessarily stimulate the building of medium-sized vessels of moderate speed and of large cargo capacity which are capable of earning dividends without the aid of large government subsidies.

In America all hopes of a boom in shipbuilding during the present year were destroyed by the defeat in Congress of the ocean mail subsidy bill providing an increased mail subsidy to ships of 16 and 14 knots speed running to South America, the Philippines, China, Japan and Australasia. This is the third time in two years that substantially the same measure has been defeated, and always on the same grounds. Opponents of the measure are, however, gradually losing ground, and, with the advent of the new administration, it is confidently believed by many that success is at hand. It seems hardly possible that a measure which has received the endorsement of both great political parties, and which has received the hearty support of two successive administrations, can much longer be suppressed.

Progress of Naval Vessels.

The Bureau of Construction and Repair, Navy Department, reports the following percentages of completion of vessels for the United States navy:

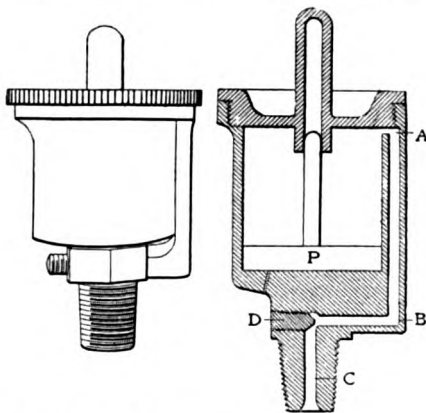
BATTLESHIPS.					
	Tons.	Knots.		Feb. 1.	Mar. 1.
S. Carolina..	16,000	18½	Wm. Cramp & Sons.....	78.9	82.3
Michigan ...	16,000	18½	New York Shipbuilding Co..	89.7	93.0
Delaware ...	20,000	21	Newp't News Shipbuilding Co.	64.1	68.5
North Dakota	20,000	21	Fore River Shipbuilding Co..	70.6	74.5
Florida	20,000	20¾	Navy Yard, New York.....	3.3	4.8
Utah	20,000	20¾	New York Shipbuilding Co..	3.1	5.6
TORPEDO-BOAT DESTROYERS.					
Smith	700	28	Wm. Cramp & Sons.....	65.2	67.8
Lamson	700	28	Wm. Cramp & Sons.....	63.8	66.3
Preston	700	28	New York Shipbuilding Co..	59.3	60.2
Flusser	700	28	Bath Iron Works.....	55.3	60.6
Reid	700	28	Bath Iron Works.....	54.6	60.0
Paulding ...	742	29½	Bath Iron Works.....	3.7	5.0
Drayton	742	29½	Bath Iron Works.....	3.7	5.0
Roe	742	29½	Newp't News Shipbuilding Co.	10.2	17.6
Terry	742	29½	Newp't News Shipbuilding Co.	9.5	17.1
Perkins	742	29½	Fore River Shipbuilding Co..	6.7	11.7
Sterrett	742	29½	Fore River Shipbuilding Co..	6.7	11.7
McCall	742	29½	New York Shipbuilding Co..	5.8	8.2
Burrows	742	29½	New York Shipbuilding Co..	5.8	8.1
Warrington..	742	29½	Wm. Cramp & Sons.....	6.2	8.4
Mayrant	742	29½	Wm. Cramp & Sons.....	6.5	8.1
SUBMARINE TORPEDO BOATS.					
Stingray	...	...	Fore River Shipbuilding Co..	69.9	77.5
Tarpon	...	...	Fore River Shipbuilding Co..	71.0	76.2
Bonita	...	...	Fore River Shipbuilding Co..	68.4	71.5
Snapper	...	...	Fore River Shipbuilding Co..	65.6	71.0
Narwhal	...	...	Fore River Shipbuilding Co..	70.0	74.4
Grayling	...	...	Fore River Shipbuilding Co..	64.7	70.7
Salmon	...	...	Fore River Shipbuilding Co..	61.3	64.2
Seal	...	...	Newp't News Shipbuilding Co.	0.0	4.6

ENGINEERING SPECIALTIES.

A Loose Pulley Oil Cup.

The Lawson Manufacturing Company, Buffalo, N. Y., has placed on the market a new oil cup for keeping loose pulleys constantly oiled while in operation. The cup consists of three distinct parts—a body, piston or plunger, and an oil-tight cover, all parts being made of a special Swiss brass, highly polished.

The cup is filled with ordinary lubricating oil by unscrewing the cover after making sure that the plunger is pushed clear

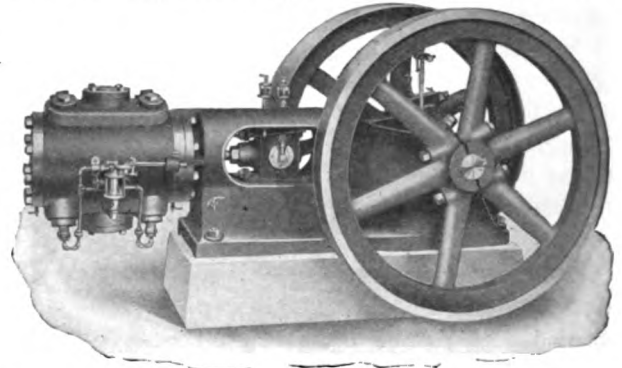


down. After the cup has been filled, the cover is then replaced and the device is ready for use. A stem with standard threads screws into the hub of the pulley. When the pulley begins to revolve, centrifugal force causes the piston in the cup to force itself upward, thus forcing the oil to flow down through the by-pass to the shaft on which the pulley is revolving. The flow of the oil is controlled by a screw which must be regulated according to the speed of the pulley. When the pulley stops, oiling ceases at once, but begins again just as soon as the pulley is started. The cup is made in two sizes, one for pulleys having diameters from 6 to 12 inches, and the other for pulleys having a diameter above 12 inches.

Dallett Air Compressors.

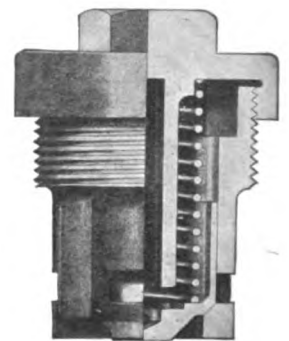
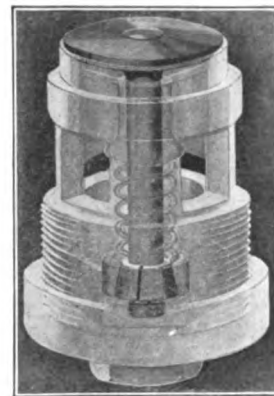
A line of air compressors built by Thos. H. Dallett & Company, Philadelphia, Pa., shows many excellent and unique ideas in design. These compressors are designed so that all parts requiring adjustment or renewal are readily accessible, and by using a liberal amount of metal, rigidity in operation is insured. The capacity of any compressor may be increased by replacing its air cylinder by that of its next larger size.

The frame is of the open-fork center crank type. The duplex belt, duplex steam and single steam machines are supported on a deep, rigid sub-base, thus making the entire machine self-contained. The main bearings are lined with a high grade of Babbitt metal, which is poured into dove-tailed recesses and well pinned in to prevent shrinkage. Lubrication is



effected by sight-feed devices, gravity or a force-feed system, drainage being provided for all drips from the guides, stuffing-boxes and the crank pit.

The steam cylinder and valve gear of the steam-driven machines are well suited to the operation of compressors, giving high efficiency with little attention. The clearance has been reduced to a minimum. A plain *D* balanced slide valve is used on the small and medium-sized machines, while the Meyer balanced, adjustable, cut-off valve is used on the large machines. The rocker arms on all valve gears are adjustable to compensate for wear. On the steam-driven machines, the



governor is equipped with a safety-stop device, which stops the machine on a breaking of the governor belt. The governor pulley is placed on the end of the shaft outside of the fly-wheel on the single machine, thus bringing the fly-wheel as close to the bearings as possible, and also preventing oil or grease, thrown by the eccentric, from getting on the governor belt. A reducing valve is used on the duplex compressors with compound steam cylinders, which reduces the live steam pressure for use in the low-pressure cylinder. If the high-pressure side stops on the dead center, live steam is fed to the low-pressure cylinder through the reducing valve for starting. The live steam is taken into the low-pressure side only when starting, otherwise the operation is identical with any compound machine.

The air cylinders are of special hard, close-grained iron, and each is thoroughly tested under hydraulic pressure of 200 pounds before assembling. The clearance space is reduced to a minimum, and all heads and cylinder walls are thoroughly water-jacketed. Oil is fed directly into the intake passage, and the suction carries it into the cylinder in the form of a fine spray.

The cross head is a new type box pattern, made of semi-steel. The shoes are adjustable and have large bearing surfaces. The upper shoe is lubricated by a sight-feed lubricator, and the lower one runs in oil. One of the features of this design is the side openings, which allow easy access to the binder nuts. The intake valve, of the automatic poppet type, is contained in a malleable iron cage. The cage is one piece, and combines both seat for the valve and guide for the valve stem. The cage is threaded, and screws into the wall of the air-intake chamber only, and is simply seated in a recess on the main cylinder wall. The valve proper is a special alloy hardened steel, with seat and stem ground to gage. The valve spring is of phosphor bronze. To eliminate the shearing off or loosening of valve spring holders, the "Dallett" spring holder comprises a split taper ring set into a recess on the valve stem, and held together by means of a solid taper ring slipping down over it. The hammering of the valve on its seat tends to tighten the spring holder on the stem instead of driving it off. The discharge valve is of the automatic poppet type, contained in a valve cage of malleable iron. The method of seating in the cylinder and locking to its seat is identical with that of the intake valve.

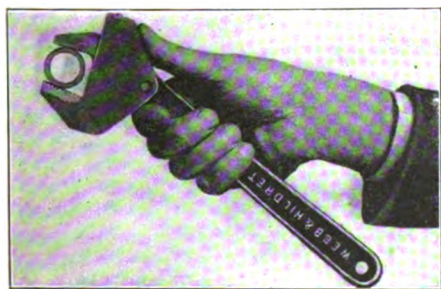
The inter-cooler plays a very important part in the economical operation of a two-stage machine. The "Dallett" inter-cooler employs the return-flow type of water circulation, using baffle plates to deflect the flow of air and in its effectual contact with the cooling tubes. The nest of cooling tubes may be removed intact from the inter-cooler box without disturbing any of the piping, as unions are supplied.

Automatic regulation of the supply of air is secured by an unloading device. When a certain determined pressure is reached in the air receiver, one or more inlet valves are held open, and the load is taken off the compressor, allowing it to run light until the pressure drops in the receiver, upon which the valves are released and air compression is resumed. On the steam machines a combined speed and pressure governor is used.

The Dallett compressors are built in sizes ranging from an 8-inch stroke up to a 16-inch stroke, giving a range of capacity from 79 cubic feet of free air per minute to 1,200 cubic feet.

A New Automatic Wrench.

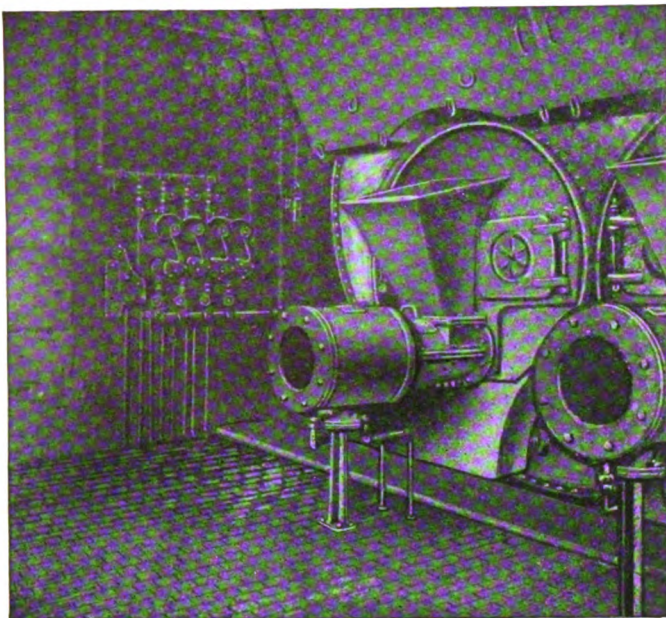
The Webb & Hildreth Manufacturing Company, 9 Forest street, Gloversville, N. Y., recently placed on the market a new type of automatic wrench, which can be quickly adjusted



for use on pipe, nuts, lag screws, etc. As shown by the illustration, the wrench is simply constructed and convenient to handle. It is claimed that the wrench is perfectly reliable.

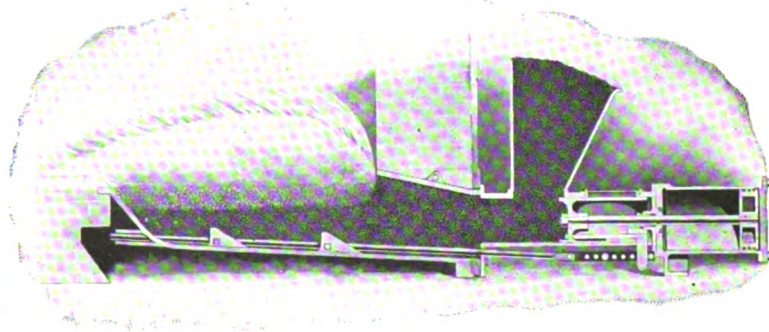
The Jones Underfeed Mechanical Stoker.

Economy in fuel, steady steam and increased efficiency, saving in labor and the abatement of smoke are the principal advantages claimed for the Jones underfeed mechanical stoker, manufactured by the Underfeed Stoker Company of America, Detroit. For several years stokers of this type have



been successfully used on land, but it is only recently that the marine stoker has been developed. All the advantages secured in stationary installation are obtained on board ship, with the added advantage that some of the hardest labor ordinarily performed on shipboard is eliminated. As shown in the illustration, coal is fed into the hopper, and from there forced by a ram underneath the fire. The ram is operated by a piston working in a steam cylinder. Due to the limitations of space on board ship, the regular type of Jones stoker has been modified by shortening the cylinder and ram case, effecting a reduction of nearly 18 inches in the length of the external parts. The internal construction remains the same as in the standard type of stoker.

Jones stokers have been installed on a number of large lake steamships with favorable results. On the *James E. Davidson*, of 6,206 gross tons, it is claimed that these stokers, in connection with Niclausse boilers, effected a saving of 25 percent in coal consumption, while on the *Eugene Zimmerman*, of 5,630 gross tons, fitted with Scotch boilers, it is claimed that the fuel bill for a single season was \$1,000 less than that of a sister ship hand fired. Furthermore, the vessel



was able to carry six thousand tons more cargo on each round trip, and traveled 1,000 miles more than her sister ship during the season.

A Patent Overload Detector for Cranes.

The illustration shows a patent overload detector for cranes, manufactured by Samuel Denison & Sons, Hunslet Foundry, Leeds. This apparatus is intended to form a permanent part of the crane chain, and not to be detachable at will.

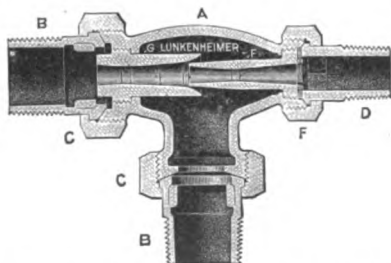
The detector gives instantaneous warning if a load greater than that for which the crane was designed is lifted, even if



it is only 1 inch off the floor. With this attachment, therefore, there can be no excuse for a workman to damage an expensive crane equipment by overloading or working it beyond its capacity. Not only is damage to the crane prevented, but serious accidents in the shop are likewise eliminated.

An Improved Ejector.

In the improved ejector manufactured by the Lunkenheimer Company, Cincinnati, Ohio, the tubes are made of a very hard grade of bronze, especially adapted for the severe service to which ejectors are generally subjected. They are screwed into the body of the ejector instead of being secured by means of unions. The latter is the method generally employed, but it has been found that tubes become lost or damaged when re-



moving the union; therefore the improved method of construction has been adopted. It is claimed that this ejector is especially economical because of the improved shape of the tapers inside the tubes, which require a less amount of steam for lifting a given quantity of water than other types of ejectors. To operate the device it is only necessary to turn the steam on full head, and after getting the flow of water established the steam can be throttled to a very low degree. As shown by the following tables, the ejector is capable of lifting water at a high temperature to a great height, and also forcing it against a great head. The ejector is made in sizes capable of

lifting from 250 to 1,100 gallons of water per hour at 75 degrees F. to a height of 20 feet, with a steam pressure of 50 pounds.

The following tables give the amount of lift, together with the height that the ejector will force when placed about 5 feet above the water level:

LIFT OF EJECTOR GIVEN IN FEET. FEED WATER 75 DEGREES F.

Pres., lbs..	5	10	15	20	25	30	40	50	60	70	80	90	100
Lift, feet..	3	7	11	15½	21	21	20	19	18	17½	16½	15½	14½

Height (in feet) ejector will force when placed 5 feet above water level:

FEED WATER 75 DEGREES F.

Pressure, pounds.....	20	30	40	50	60	70	80	90	100
Height, feet.....	18	28	36	46	57	66	74	84	92

TECHNICAL PUBLICATIONS.

Notes and Drawings of a Four-Cylinder Petrol Engine.

By Henry J. Spooner, C. E. Size, 15 by 10½ inches. Pages, 16. Plates, 11. London, 1908: Longmans, Green & Company. Price, 2s.

The author, from a long and varied experience in teaching in technical schools and colleges, has found that there is a great scarcity of drawings of complete machines, and, realizing that if students are to become useful draftsmen, they must not only become proficient in drawing details of machines, but they must also be able to correctly project one view from another, to make additional sectional views and to exercise their judgment in deciding upon suitable sizes for the many little refinements and minor details which would be necessary for them to decide in designing a complete machine. For this reason complete drawings of a petrol engine are given, this type of engine being selected chiefly from the interest which engineering students take in all that pertains to motor engineering. For the benefit of those who are not acquainted with the details of this type of engine, the various parts and the operation of the engine are carefully described.

Textbook of Theoretical Naval Architecture. By Edward L. Attwood. Size, 4¾ by 7¼ inches. Pages, 458. Figures, 145. Plates, 5. London, 1909: Longmans, Green & Company. Price, 7/6 (\$2.50).

The fact that five editions of this book have been called for since it first appeared in 1899 gives a good idea of the value of the work. It was originally written in order to provide students and draftsmen engaged in shipbuilders' and naval architects drawing offices with a convenient textbook which would explain fully the ordinary calculations pertaining to ship design. The book is not confined, however, to a description of elementary calculations, for the latter part of the book is intended to serve as a textbook for the theoretical portion of the examinations of the Art and Science Department in Naval Architecture at the Royal Naval College, Greenwich.

A valuable feature of the book is the large number of examples given in the text and at the ends of the chapters, by means of which the student can test his grasp of the principles and methods described in the text. Most of these examples have been taken from actual drawing-office calculations, so that the student may get a good idea of the sort of work which will be required of him in such an office.

There are eight chapters, dealing, respectively, with areas, volumes, weights, displacement, etc., moments, center of gravity, center of buoyancy, displacement measurements, etc., conditions of equilibrium, transverse metacenter, moment of inertia, metacentric height, etc., longitudinal metacenter and change of trim, statical and dynamical stability with calculations of weights, strength of butt connections, stresses in ship structures, and resistances and propulsion.

The Story of the Submarine. By Col. C. Field. Size, $5\frac{1}{4}$ by 8 inches. Pages, 304. Over 100 illustrations. London, 1908: Sampson Low, Marston & Company, Ltd. Price, 6s. (\$2.00).

A large part of this book is of an historical nature, describing the early development of submarine boats and other apparatus. The book does not claim to be a work of reference, but is rather intended to satisfy the curiosity of the casual reader. Technicalities and diagrams which would be of value in a scientific work are, therefore, omitted, and the various phases of submarine warfare are described in a very general way. Perhaps no branch of marine engineering has appealed so much to the imagination of inventors as submarine navigation. At any rate, the great number of impractical and amusing schemes which have been evolved will readily appeal to the imaginative reader, affording him entertainment if not instruction.

Suction Gas Plants. By C. Alfred Smith, B. Sc. Size, $5\frac{1}{4}$ by $7\frac{1}{2}$ inches. Pages, 198. Illustrations, 55. London, 1909: Charles Griffin & Company, Ltd. Price, 5s. net.

Recently a special course of three lectures on suction gas plants was given at the East London College. This course aroused such widespread interest that numerous requests were made for the publication of the subject matter. This work, therefore, includes the text and illustrations of these three lectures, the first lecture taking up the details of construction of apparatus, the production of steam, fuel and testing. The second lecture describes the operation of typical plants and the application and uses of suction plants. The third lecture describes plants for special purposes, pointing out the advantages and disadvantages of a suction gas plant, and giving some data on the cost of gas production. The book undoubtedly comprises the most complete treatment of suction gas plants which has yet come from the press.

Les Flottes de Combat en 1909. By Commandant Balin-court. Size, 6 by $4\frac{3}{4}$ inches. Pages, 751. Figures, 357. Paris and Nancy, 1908: Berger-Levrault & Company. Price, 5 francs.

The previous editions of this book have been carefully reviewed in our columns, so that an extended description of the work is unnecessary. This is the eighth edition, and comprises the usual features which are incorporated each year, namely: the illustration and description of the principal features of all important warships in the world, classified according to the nations to which they belong. The illustrations consist of line drawings, showing the outboard profile and the deck plan of the vessels, indicating the positions of guns and armor as well as the size of guns and thickness of armor. A description of each vessel includes the principal dimensions, horsepower, speed and steaming radius, the number and size of the guns carried, and the extent and thickness of armor.

A new feature which has been introduced into the present edition is a recapitulation of the naval strength of each country, in which the total displacement and number of guns of different sizes are given for each class of ships in the navy. This affords an opportunity for the reader to obtain at a glance an accurate idea of the comparative sizes and offensive powers of the different navies of the world.

OBITUARY.

Ervin Saunders, vice-president of D. Saunders Sons, Inc., died at Yonkers, N. Y., Wednesday, February 17.

Henry Bausch, second vice-president of the Bausch & Lomb Optical Company, died at Augusta, Ga., March 2. Mr. Bausch has been identified with the Bausch & Lomb Optical Company during his entire lifetime, his father having been one of the organizers of the business.

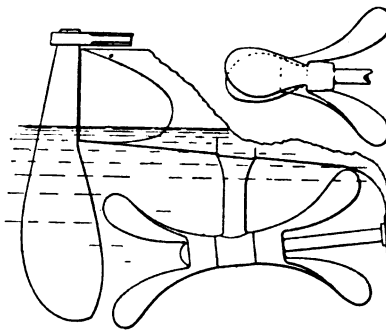
SELECTED MARINE PATENTS.

The publication in this column of a patent specification does not necessarily imply editorial commendation.

American patents compiled by Delbert H. Decker, Esq., registered patent attorney, Loan & Trust Building, Washington, D. C.

865,864. PROPELLER. FREDERICK A. DOUSE, OF SEATTLE, WASH.

Claim 3.—In combination with a shaft, two propellers, each consisting of a hub having oppositely flattened surfaces and with two helical blades extending from the remaining opposite sides of the hub in diverging



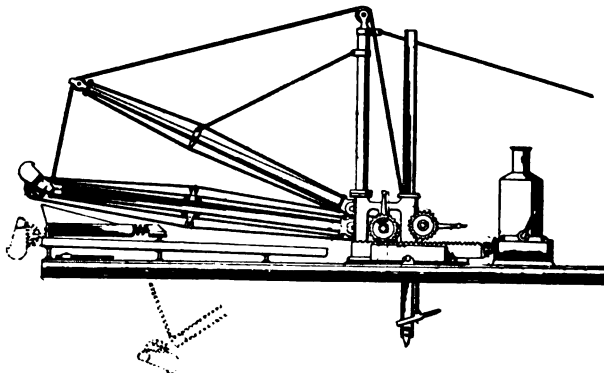
curved lines and increasing in pitch and likewise in width toward their free end and arranged upon the shaft and with the blades extending in opposite directions. Three claims.

908,690. DIVING GEAR OR THE LIKE. ALOIS NEUBERT, OF NEW YORK, N. Y., ASSIGNOR TO A. SCHRADER'S SON, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

Claim 1.—In a diving apparatus or the like, the combination of an air tube through which the air is led to the operator, and a trap connected with such tube and adapted to receive moisture therefrom, such trap comprising an enlarged chamber into which such tube leads, whereby the moisture cannot follow the tube to the operator. Twenty-three claims.

909,068. GOLD DREDGE. HORACE J. CLARK, OF CHICAGO, ILL., ASSIGNOR TO CLARK DREDGE MANUFACTURING COMPANY, OF CHICAGO, ILL., A CORPORATION OF MAINE.

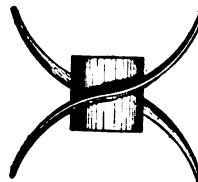
Claim 1.—In a dredge, the combination with a hull having a longitudinally extending channel opening, of a scoop arm pivotally mounted



in said opening intermediate of the ends of the hull, and an oscillating scoop upon the free end of said arm adapted to discharge upon one end of said hull. Twenty-seven claims.

909,246. PROPELLER. EDMUND D. SPEAR, OF BOSTON, MASS.

Claim 2.—A propeller comprising a hub and a plurality of blades, each



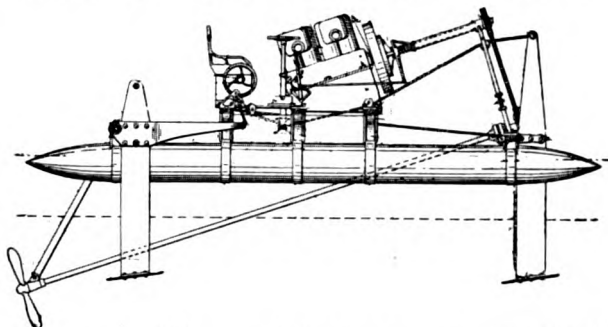
of which has a driving surface in the form of a convex conchoidal curve extending transversely thereof. Two claims.

910,899. REVERSING PROPELLER. OLIVER A. BOWERS, OF MILFORD, MASS., ASSIGNOR TO C. F. ROPER & CO., OF HOPE-DALE, MASS., A FIRM.

Claim 1.—A shaft adapted to be rotated in one direction at a substantially uniform speed, a propeller mounted thereon comprising two oppositely located and angularly-movable blades, and a single means to reverse the angularity of said blades and connected with both, said means operating to turn one blade to full reversed position while holding the other blade in its original position and thereafter turning the last-mentioned blade to its full reversed position while the first-named blade is maintained in full reversed position. Nine claims.

909,468. HYDROPLANE BOAT. LOWE E. SIMPSON, OF COLLEGE HILL, OHIO.

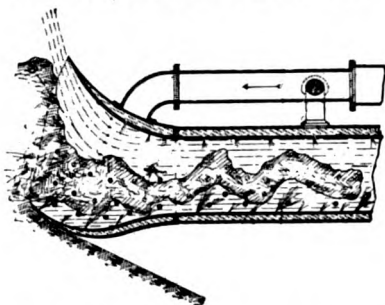
Claim 2.—In a hydroplane boat, the combination of a normal supporting body, hydroplane frames pivoted thereto, said hydroplane frames comprising hydroplanes, a pivoted manipulating drum, and flexible con-



nections between said drum and hydroplane frames whereby said hydroplane frames may be simultaneously swung about their pivots by revolving said drum, and whereby said hydroplane frames may be manipulated by swinging said drum upon its pivot. Seven claims.

909,543. DREDGING APPARATUS. JULIO CARLESIMO, OF BUENOS AYRES, ARGENTINA.

Claim 1.—In a dredging apparatus, a suction device comprising an outer conduit, a conduit mounted within the latter forming a chamber,

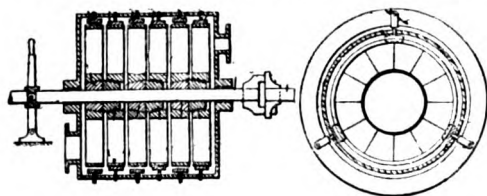


means to supply a lubricant to said chamber, and means to inject the lubricant from said chamber onto the material passing through the inner conduit. Five claims.

British patents compiled by Edwards & Co., chartered patent agents and engineers, Chancery Lane Station Chambers, London, W. C.

19,958. TURBINES. A. FAYWISCHEWITSCH, MITTWEIDA, GERMANY.

A turbine comprising alternate sets of fixed and movable blades or disks is reversed by coupling the fixed blades to the shaft, and at the same time uncoupling the previously movable blades and clamping them to the casing. The shaft is provided with conical wheels having screw threads on their surfaces adapted to engage with the screw threads provided on the interior surfaces of the hubs of the disks, the adjacent cones being oppositely inclined. The alternate disks are in engagement with the shaft, the others being free from the screw threads on the wheels and held stationary by clutches passing through the casing. The

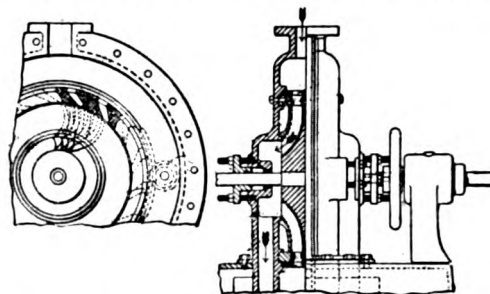


clutches are actuated by rings outside the casing, the rings having cam-slots which actuate the clutches when the wheel is turned. The clutch may engage with a groove in the peripheral edge of the disks and is forked at its outer end, the forked members being joined by a bolt which passes through the cam-slot in the disk. Similar rings with oppositely-inclined cam-slots are provided for the clutches which hold the alternate disks when the engine is reversed, the inertia of the shaft causing it to continue to rotate after the disks are stopped by the clutches. The shaft thus unscrews itself from the hubs and is then given the necessary longitudinal movement to cause it to engage with the other set of hubs. The remaining disks are simultaneously released from the clutches. A special coupling connecting the main shaft with the driven shaft allows the necessary longitudinal movement to be given by a lever without breaking the connection. The clutch-actuating rings may be connected together, so that one movement causes the engagement of one of the sets of clutches and the disengagement of the other set.

20,130. TURBINES. W. B. MILLER, CHRISTCHURCH, NEW ZEALAND.

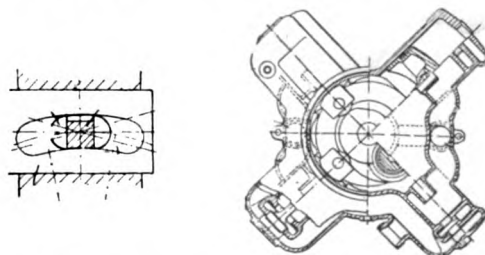
A duplex inward-flow turbine is constructed as shown. Steam from an annular chest is delivered by nozzles upon gouge-shaped rotor blades on each side of a disk and exhausts in an axial direction into a chamber.

The nozzle ports are formed in an annular partition and are controlled by a slide ring-valve actuated by a rack and pinion, the spindle of the pinion being provided with a hand wheel outside the casing. Rings



secure the outer edges of the blades, and alternate blades are shortened to provide a free exit for the steam. The joints and bearing faces are made steam tight. Several forward engines and a reversing engine may be arranged on the same shaft.

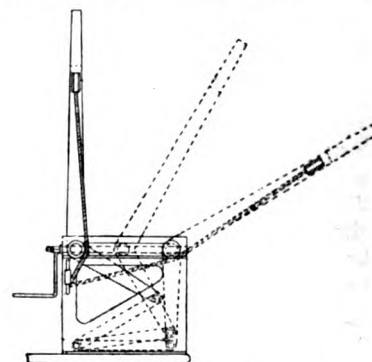
20,274. SCREW PROPELLERS. H. PAWLIK, BUDAPEST. Relates to mechanism for varying the pitch by turning the blades in their settings. Each blade carries a stud in a guide piece moving in the curved guide slot of a slide capable of being longitudinally displaced along the propeller shaft. The blades are journaled in that part



of the boss outside the slide by means of a thickened end of the blade, which is retained by caps and has its bearing in shells. Owing to the curved shape of the slots the movement of the slides necessitates a slight transverse motion of the studs relatively to the slide.

20,801. BOAT-RAISING GEAR. S. HANCOCK, WEST BRIDGFORD.

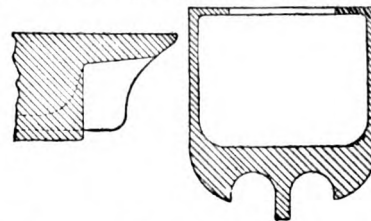
The boat davits have the lower ends bent at an angle to the upper parts and are supported on rollers moved in a slot in a frame by a screwed spindle. Radius bars mounted on a pin are attached to the



lower end of the davits, and when the davits are outboard the radius bars are horizontal and the lower ends of the davits vertical. The fall of the boat tackle is led through a guide and round a sheave on the davit trunnion, causing the boat to be slightly raised as the davit travels outboard.

21,429. SHIPS' HULLS. A. JAKOBSEN AND G. HUGHES, GRIMSBY.

The hulls of vessels are provided along each side of the keel with a shallow groove which does not encroach upon the hold space. These



grooves run the full length of the ship and lead into a recess or open chamber extending upwardly into the stern beyond the end of the keel. The grooves are stated to add to the ship's stability and prevent excessive rolling.